POWER

Volume 61 New York, February 17, 1925 *No.* 7

Good Will

A FRIEND and subscriber sends in this well-expressed definition:

> It is the disposition of a pleased customer to return to the place where he has been well treated.

The business that has a sufficient number of this kind of customers is assured of a continued and prosperous existence.

How many times you go blocks out of your way to buy something at a place where you have found pleasant, interested attention and where the things that you have bought have given good and satisfactory service!

How persistently you avoid a place where recollections of a surly salesman are associated with your use of your purchases, the goods from which have been unsatisfactory, or where advantage has been taken of your confidence!

A smart salesman may gain a temporary advantage for his house by getting the better of a careless buyer on price, by working off on him an unsalable or damaged article or by overselling him, but he is building up ill will rather than good will and his trade will soon come to be precariously dependent upon that genus of the members of which it is said that one is born every minute.

In the engineering trade there is a special opportunity for the creation of good will. The customer is often dependent upon the salesman for a knowledge of what is best adapted to his needs, in size and capacity and often in kind.

The salesmen of many kinds of apparatus and of supplies are virtually in the position of technical advisers, and the sales engineer who resists the temptation to sell more capacity or a better grade than the job warrants, or who even advises against the purchase of his goods or appliances when they are not necessary for or best adapted to the required service, will make more friends, win more confidence, cultivate more good will and sell more goods in the long run than the one whose constant aim is an immediate large order rather than a permanently satisfied customer.

F. R. Low

Long Beach Steam Station of the Southern California Edison Co.

By FRANK S. CLARK and M. W. CARTY
Stone & Webster, Inc.

Outstanding Features

Capacity of plant, 70,000 kilowatts.

First modern high-pressure steam plant west of Rocky Mountains.

Speed of construction: Ten and one-half months from breaking ground to commercial operation.

Combination oil and gas burners.

Furnace walls under forced-draft ventilation using the ventilating air for combustion.

Triple intake tunnels to take care of marine growths.

Central priming system for pumps and condensers.

Double-wound squirrel-cage motors for auxiliary drive.

THE electric power system of the Southern California Edison Company supplies a territory extending from Los Angeles northward to beyond Fresno, a distance of over 200 miles, and southward to Laguna Beach, a distance of about 45 miles. Hydro-electric generating stations located in the Sierra Nevada and San Bernardino Mountains and high-tension transmission lines delivering the energy to cities and towns hundreds of miles away, with supplemental steam power stations at Long Beach, Redondo and Santa Barbara, evidence a comprehensive development for supplying power and light to the rapidly growing communities of southern California.

Toward the end of the year 1923 the Southern California Edison Company decided that the next development to supply the increasing demands for electric energy in this district could most economically be had by the construction of a 70,000-kw. steam-generating station at Long Beach, about 20 miles from the center of Los Angeles. Stone & Webster, Inc., was engaged to design and construct the station which is known as Long Beach Steam Plant No. 2. The new station has an effective capacity of 70,000 kw. in two units of 35,000 kw. capacity each. These are the largest steam-driven turbines west of the Rocky Mountains. The steam conditions adopted, 375 lb. pressure and 700 deg. F. temperature, are also higher than in any existing stations on the Western Coast.

The site selected adjoins the company's present Long Beach Steam Plant No. 1, which is on an island in the

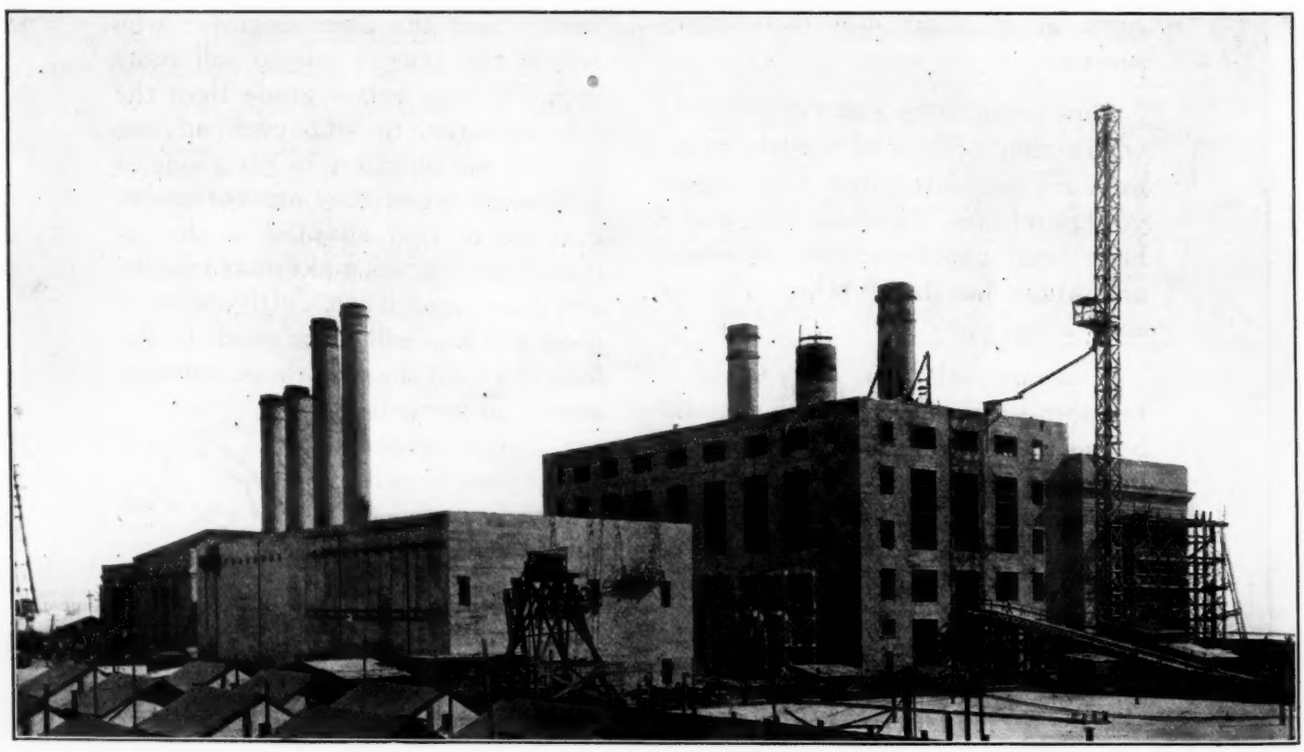


Fig. 1—New station adjacent to Plant No. 1

outskirts of Long Beach. An unlimited supply of condensing water is available from the Pacific Ocean. A railroad connection is also provided into the plant. The station went into service on December 1, or a little more than ten months from the date of starting operations in the field, a remarkably short time for the design and construction of a plant of this size and type.

Reference to the cross-section of the station, Fig. 2, shows the shafts of the turbo-generators parallel to the length of the turbine room and the boiler-room firing aisle is parallel to the turbine shafts. This arrangement affords excellent light and ventilation throughout the plant and places most of the auxiliary equipment in the turbine room, where it is accessible to the crane hooks. This design also results in an economical building requiring only about 0.50 sq.ft. of ground floor area and about 50 cu.ft. of space per rated kilowatt of installed generator capacity, omitting the separate switchhouse from consideration.

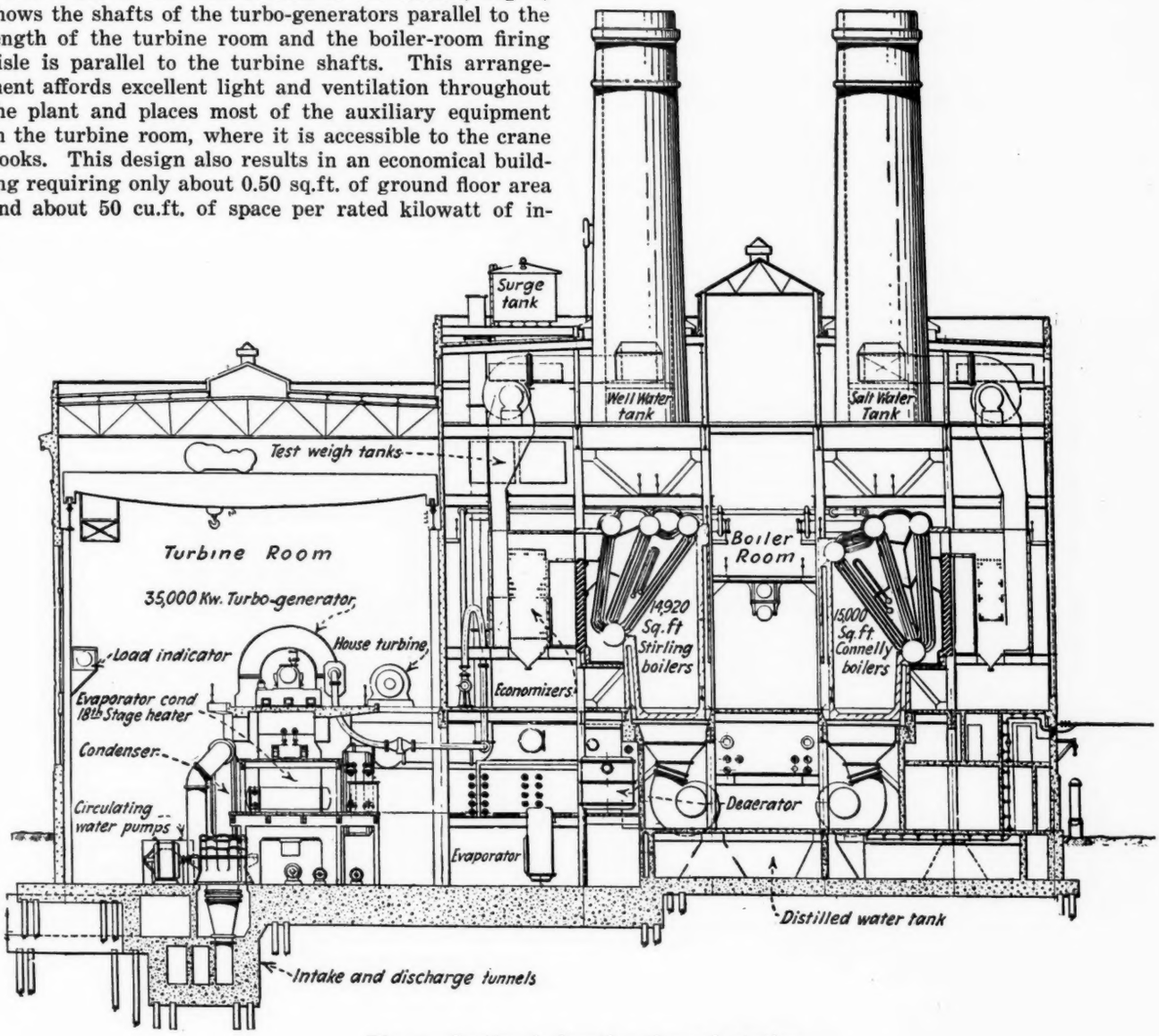


Fig. 2—Sectional elevation through station

The space under the boiler-room basement floor is utilized for distilled-water storage tanks, for tunnels for generator leads and for a cable vault.

Eight boilers of approximately 15,000 sq.ft. are installed and designed for 400 lb. working steam pressure. Boilers of the Stirling type were selected because of their lower cost than the sectional header type and for the reason that they permit large furnace volumes to be used without excessive height of setting. Their slightly less efficiency is compensated for by increasing the size of the economizers. These are of the steel-tube type, and each has a heating surface equivalent to about 75 per cent of the heating surface of the boiler with which it is installed. Air for combustion is provided by individual forced-draft fans of 60,000 cu.ft. capacity each. The air ducts are not cross-connected. Induced draft is supplied by fans of 110,000 cu.ft. capacity each, there being one fan per boiler.

The main switching equipment is in a separate building where the apparatus and buses are protected from the salty atmosphere prevalent during some seasons of the year. The auxiliary switches are installed in an inclosed section of the boiler-house basement.

Soil conditions required the use of piling, and wood piles averaging 40 ft. long were used, capped by a concrete mat and with piers to support the building columns. Over the area of the turbine room where the auxiliary equipment is installed, a 2-ft. upper fill of concrete was left unpoured until the exact positions of anchor bolts, conduit runs, drainage piping and floor trenches were known. The circulating-water tunnels are tied into the turbine-room mat, the whole construction providing a solid foundation for the turbo-generator supports. These are of concrete and carry a load in excess of 1,000,000 lb. each.

The building is of structural steel framing with self-supporting concrete walls, floors and roof, all of fireproof construction. Four reinforced-concrete stacks 13 ft. 4 in. internal diameter by 74 ft. high are superimposed upon the building steel frame. The lower part of each stack below the entrance level of flues is utilized for water storage. The offices and conveniences for the operating force are provided at one end of the turbine room and on a mezzanine floor in the basement of the boiler house, where a small station supply room is also located.

Main Turbo-generators and Condensers

The two main turbines are 20-stage single-cylinder type designed for four-point bleeding. The main generators are each rated at 35,000 kw. 50 cycle three-phase 11,000 volts and the auxiliary generators are 2,800 kw. three-phase 2,300-volts, direct connected to the main

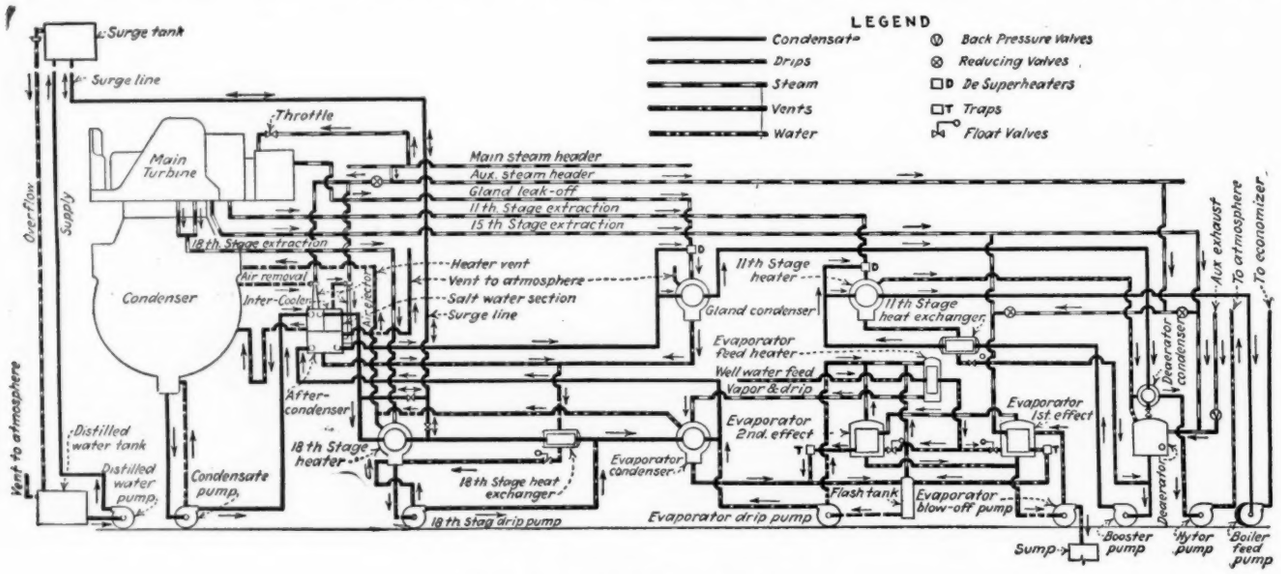


Fig. 3—Heat-balance diagram

generators and provided with direct-connected exciters. Auxiliary power is thus available at a generating efficiency practically equivalent to that of the main units without, however, necessitating any form of electrical connection with the main power system. The main turbines are capable of operating the main generator and auxiliary generator to deliver a combined output of 40,000 kw. The water rate of the turbines at full load is 10 lb. per kw.-hr. without steam extraction. The closed system of generator air cooling is employed with fin-type tubular coolers. A system using carbon tetrachloride gas is installed to extinguish fires in the generators. A 175-kw. combination steam- and motor-driven exciter is provided for each main generator.

The two main condensers are of the two-pass radial-flow type, having 55,000 sq.ft. of tube surface per condenser. The waterboxes are divided vertically so that a condenser may be cleaned while in service. "Flow-rite" nozzles are provided in the water-inlet ends to reduce "cavitation."

Boiler Settings and Fuel Burners

The boilers are set for firing from the front wall only. The furnace walls are ventilated to prolong the life of the brickwork. This construction has a further advantage in that it reduces the loss of heat by radiation and results in a slight preheating of the air to the fuel burners. The 9-in. furnace walls bonded to the steel buckstay framework afford ample stability with greater flexibility for adjustment to expansion strains than could be had with a thicker wall, which would merely add material subject to deterioration at the high temperatures.

Air for combustion flows through the ventilating passages outside the 9-in. furnace walls of the setting at a moderate positive pressure above atmosphere rather than under a slight suction, which is the more common practice. The principal advantage of the positive pressure is that it altogether obviates the possibility of hot furnace gases soaking into the brick. Another advantage of the positive pressure is that the draft suction required within the boiler setting is only that necessary to move the gases of combustion across the heating surfaces. The use of this low suction minimizes the undesirable infiltration of air.

The positive air pressure in the ventilation passages of the setting is limited to about 1½ in. water, less than 8 lb. per sq.ft. on the brickwork. This low pressure not only makes it less difficult to maintain tightness of the walls in the ventilated areas and permits a low power consumption in forced-draft fan equipment, but reduces the flame velocities from the burners with a corresponding reduced tendency to flame and fuel impingement upon the brickwork of the bridge walls and side walls. The entire furnace floor and also the side walls and bridge walls of each furnace are cooled by the air, and the flow is adjusted for uniform distribution by definite individual passages. In general, the flow is from under the furnace floor, up the side walls, forward to the front wall, then part way across the front wall, and finally downward to the blast box at the burners.

Fifteen burners are installed per furnace, the large number being necessary to pass the required volume of air for combustion at the low air pressure. Moreover, this large number of burners results in more uniform combustion across the width of the furnace and consequently in less localization of heat at the bridge

wall than would be the case with fewer burners installed. The burners are capable of burning either natural gas or fuel oil, and a change-over from gas to oil can be made quickly. To prevent possibility of back pressure within the setting or accumulation of incompletely consumed gas in case of stoppage of the induced-draft fans, the admission of fuel into the furnace is automatically cut off when a fan ceases to operate.

Condensing-Water Tunnels

The circulating pumps for the main condenser have a capacity of 44,000 gal. per min. each. Two pumps are provided for each condenser. The intake tunnels extend from the ship entrance channel to the station, a distance of about 1,100 ft. and the discharge tunnel extends from the station to the beach, which is about 600 ft. away. The bottom of the entrance channel is sandy, and at times the action of the waves so stirs up the sand that a considerable amount of it is thrown into suspension. Sand in the circulating water is objectionable as it cuts the condenser tubes and pump runners. Accordingly, in order to keep the sand out of the condensing system, a large settling basin is provided at the inlet end of the intake tunnels.

Marine plants and shellfish grow rapidly in the warm waters of southern California, and the accumulation of these growths is likely to restrict water tunnels and piping systems. This condition is especially objectionable when the growth occurs within the intake tunnels after passing the screens, as the particles that are continually being detached block up the condenser tubes. To provide means for limiting these growths, the intake tunnels outside of the station building are constructed in three separate units with sluice gates at each end and the intake tunnels inside the building are in two separate units. This permits pumping out the tunnels outside the building in regular order for exposure to air for one or two weeks to kill the marine growths. The discharge tunnel has a cross-sectional area of 78 sq.ft. and is constructed with a discharge weir at the beach.

Consideration was given to lining these double tunnels inside the building with sheet copper, which would have prevented the adhesion of marine growths, but it was finally decided that the life of the copper was too uncertain to justify the installation. Marine growths in the tunnels can be retarded to a considerable extent by frequently filling the tunnels with fresh water, and it is possible that this treatment could be made more quickly effective by the addition of copper sulphate. It is probable that this form of treatment will not be resorted to unless necessary, as there is a scarcity of fresh water at the site, the supply being obtained from shallow wells.

Heat Balance

The "heat balance" diagram of the station is shown by Fig. 3. Steam is extracted from the eleventh, fifteenth and eighteenth stages of the main turbine, that extracted amounting to a total of about 20 per cent of that passing through the throttles of the main units at full load. The flow of condensate through the system is shown by Fig. 5 and is planned on the "counter-flow" principle for highest efficiency, but modified as necessary to permit the auxiliary apparatus to function properly. A terminal difference of about 6 deg. F. has been assumed for the heat exchange equipment, and the condensate will enter the economizers at the boilers at a temperature of from 275 to 300 deg. F., depending upon the load.

The heat absorbed by the condensate in passing through the extraction heaters and heat exchange apparatus is equivalent to about 8 per cent improvement in the heat economy of the main turbines with no steam extraction. The gain is probably about 4 per cent in comparison with the results that would be obtained in a station with no steam extraction and without heat exchange equipment. The deaërators and the evaporators take steam from the fifteenth stage of the main turbines, and the combination of the two has the same effect as a single heater. The deaërators are of the direct-contact type and the evaporators are double-effect. Heat exchangers cool the drips to a temperature about 6 deg. higher than the temperature of the corresponding entering water.

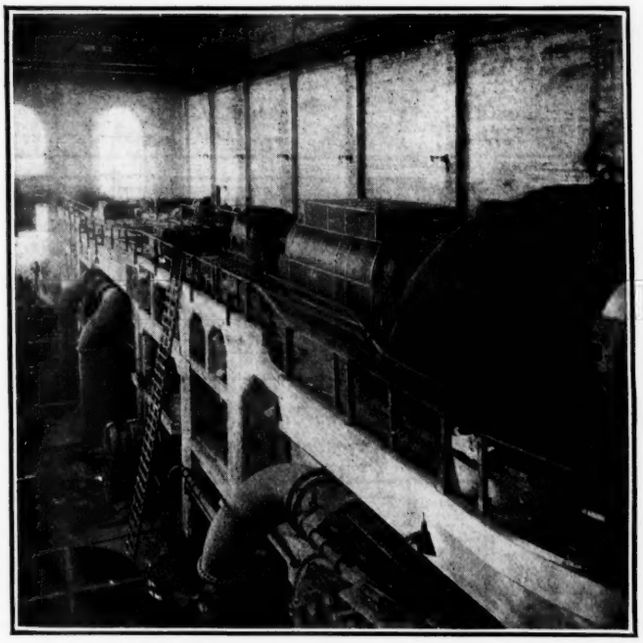


Fig. 4—View of turbine room

Auxiliary Equipment

The auxiliaries are arranged so that either main turbo-generator may be operated independently of the other unit. A house turbine may be installed later, but for the present energy available from Plant No. 1 will meet all requirements to supplement the power from the auxiliary generators which are directly coupled to the main units. All auxiliary equipment is motor driven except one boiler-feed pump, one fuel-oil pump and the two duplex-drive exciter sets. These steam-driven units are installed primarily for service in starting up the station.

Brush-shifting motors are provided for driving equipment where a wide range of speed is necessary with accurate control at any speed. Where accurate speed control is not necessary, induction motors are provided and above 7½ hp. these are of the double-wound type. The boiler-feed pumps are five-stage units receiving water at about 150 lb. from the two-stage deaërator booster pumps, the pressure in the suction to the feed pumps being ample to prevent vaporization in the line.

Sufficient capacity is provided in the deaërators for the entire boiler-feed requirements, reducing the dissolved gases to a maximum of 0.03 c.c. of oxygen per liter, and they will normally operate with an internal pressure of about 5 lb. gage. The evaporator equipments have a capacity equivalent to 4 per cent of the steam to the main turbines at full load. They are of the low-pressure submerged-tube type, are arranged so that each unit may be operated as a single effect or normally as part of a double-effect unit, and are designed to produce water containing not more than one

of the station are installed, including many recording instruments, as follows:

Main steam header—pressure.
Steam at turbine throttles—pressure and temperature.
Exhaust steam to condenser—temperature.
Auxiliary steam flow.
Condensate from condensers—temperature.
Condensate leaving heat exchange apparatus—temperature.
Condensate flow to boiler-feed pumps.
Condensate salinity.
Main condenser vacuum.
Circulating water from condensers—temperature.

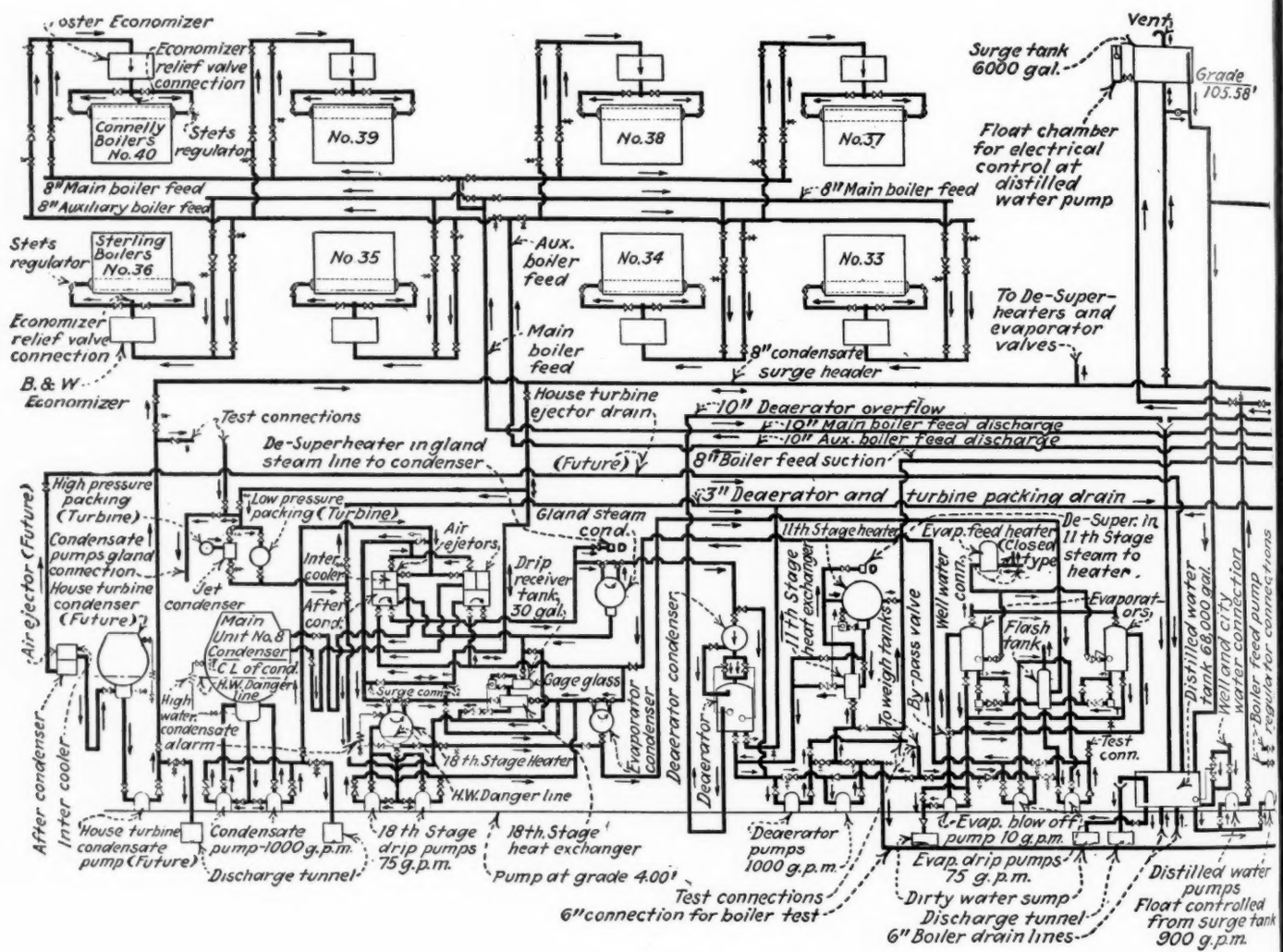


Fig. 5—Diagram showing flow of

grain per U. S. gallon of total solid impurities. They work with an internal pressure of about 5 lb. gage and are reversible for scaling the tubes if necessary.

A complete equipment of salt-water, fresh-water and sump pumps is provided, the units being in duplicate, and there are two central priming systems. The fuel-oil pumps and the oil-circulating pumps for the step-up transformers are conveniently located in one corner of the boiler-house basement. The air compressor is the only reciprocating unit in the station.

A complete test system is installed for testing the main turbines, boilers, evaporators, deaërators, and the auxiliary equipment.

All instruments necessary for the efficient operation

Circulating water flow from condensers.
Feed-water flow to boilers.
Boiler feed—pressure.
Boiler blow-off header—temperature.
Fuel gas—pressure.
Fuel oil—pressure and temperature.
Ventilating air from generators—temperature.

The usual indicating instruments are provided and also multiple-pointer gages and boiler meters and CO_2 and CO recorders for each boiler, the CO records being especially useful when natural gas is burned.

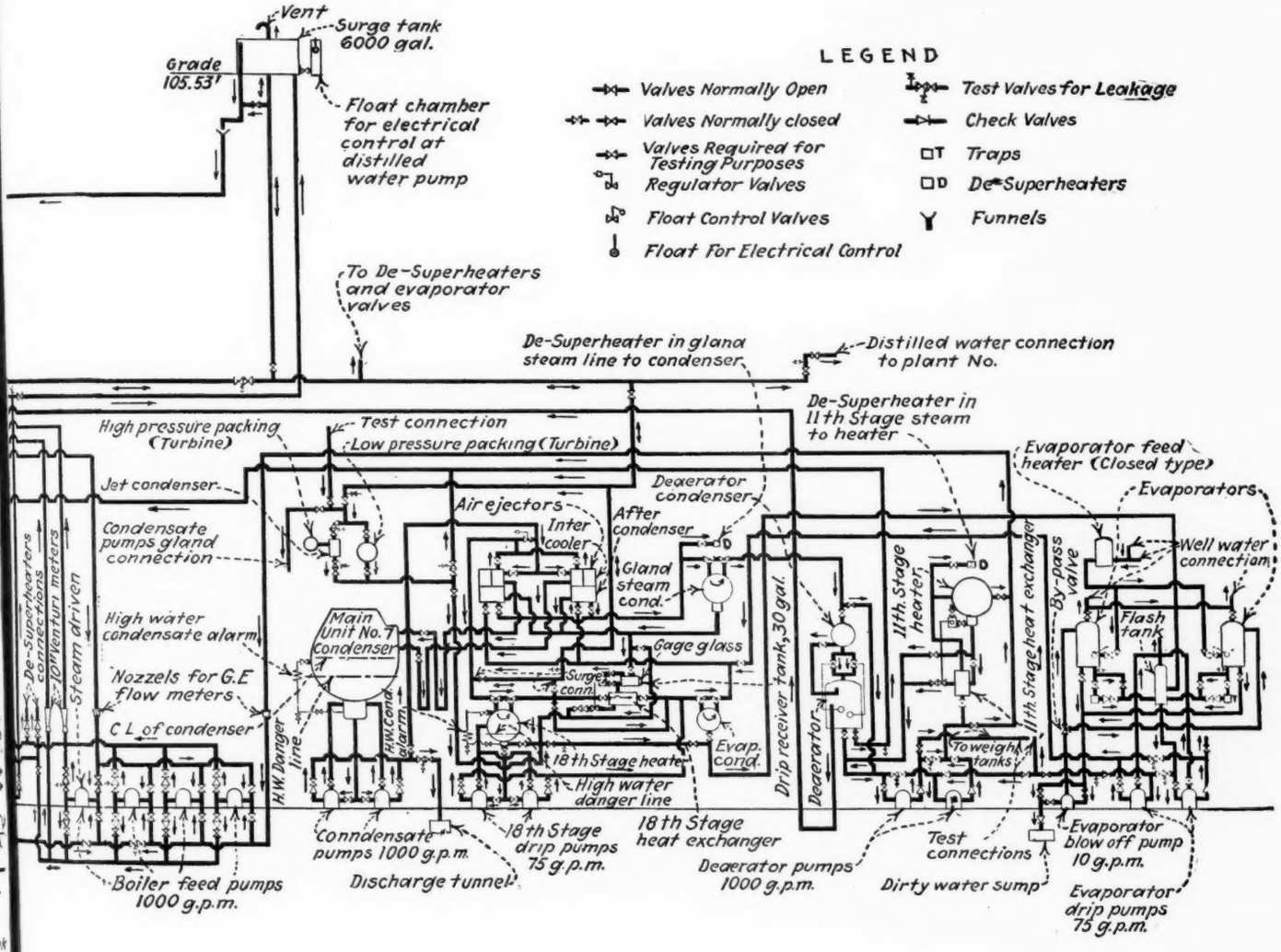
Main steam piping and the other high-pressure steam piping conform to recent 400-lb. standards with fittings having flanges for Sargol welded joints made up with Mayari steel studs and casehardened hexagonal nuts.

Exhaust piping up to 24-in. size is full-weight steel with cast-iron fittings, except in the smaller sizes. Exhaust piping 24 in. and over is cast iron 50-lb. standard in the horizontal runs, but the vertical risers from the main atmospheric relief valves for the turbines are ¼-in. welded steel-plate pipe. The boiler-feed and the boiler blowoff lines have cast-steel fittings except in the smaller sizes where forged steel fittings are used. All salt-water lines are cast iron except in the smaller sizes, where galvanized wrought iron is used.

For insulating the piping for the steam temperature

The energy from the two main units is stepped up from 11,000 volts to 72,000 volts through two banks of single-phase transformers connected delta-Y and located in the area between the main plant and the switchhouse. No 11,000-volt switching equipment is provided in the present installation, all switching operations being performed on the 72,000-volt side of the transformers.

Control for all the 72,000-volt switching equipment and 2,300-volt auxiliary power equipment in Plant No. 2, together with the 11,000-volt and 72,000-volt switching equipment in the transformer house of Plant No. 1, is



condensate through the entire system

of 700 deg. F., a double layer is applied, the layer in contact with the pipe being of special heat-resistant material suitable for this service and the outer layer 85 per cent magnesia. The total thickness is 3½ in. on the larger pipe. On the flat surfaces of heaters, boiler drum heads and smoke flues, 85 per cent magnesia block insulation is applied, securely fastened into place.

Electrical Equipment

The control and distribution equipment for the output of the plant is in the switchhouse about 75 ft. away from the boiler room, the control and distribution equipment for Plant No. 1 also being installed in this house. centralized in a 12-section radial-type control desk in the switchboard room on the second floor of the switchhouse.

A vertical control and instrument board for controlling the output of the exciters of the new plant is located on one side of the switchboard room, and similar equipment is provided on the other side of the switchboard room for the control of exciters in Plant No. 1.

In addition to the usual complement of meters and relays, a special "answer-back" generator signal system is provided for giving instructions to the turbine-room attendants in both plants by means of lamp-type annunciators mounted on pedestals adjacent to the main units. Similar annunciators without the "answer-back"

DATA ON PRINCIPAL EQUIPMENT IN LONG BEACH STEAM PLANT NO. 2 SOUTHERN CALIFORNIA EDISON COMPANY

GENERAL

Location	Long Beach, Calif.
Character of service	Base load
Capacity	70,000 kw. at 90 per cent p.f.
Boiler house, ft	196x109
Turbine room, ft	207x67
Switch house, ft	207x78
Width firing aisle	20 ft.
Floor to turbine room floor	32 ft.
Turb. room floor to crane rail	36 ft.
Turb. room floor to roof truss	48 ft.
Boiler room basement to boiler room floor	21ft. 6 in.
Boiler room floor to roof truss	67 ft. 3 in.
Designed and constructed by	Stone & Webster, Inc.

BOILERS AND SUPERHEATERS

Manufacturer	Babcock & Wilcox Co.	D. Connelly Boiler Co.
Type of boiler	Stirling Class 13	Connelly Class L-50
Number installed	4	4
Heating surface per boiler	14,916 sq.ft.	15,000 sq.ft.
Furnace volume	6,400 cu.ft.	5,600 cu.ft.
Fur. vol. per sq.ft. boiler heating sur.	0.429 cu.ft.	0.373 cu.ft.
Size of tubes	3½ in. O.D.	3½ in. O.D.
Boiler pressure	375 lb. gage	375 lb. gage
Type of superheater	B.&W. single-loop convection	Foster double loop convection
Location of superheater	Bet. first and sec. bank of tubes	Bet. first and sec. bank of tubes
Superheater surface per boiler	3,574 sq.ft.	5,780 sq.ft.
Superheater surface per sq.ft. of boiler	0.239 sq.ft.	0.385 sq.ft.
Steam tem. at 300 per cent rating	722 deg. F.	710 deg. F.
Corresponding superheat	280 deg. F.	268 deg. F.

ECONOMIZERS

Manufacturer	Babcock & Wilcox Co.	Power Specialty Co.
Type	Babcock & Wilcox	Foster
Location	Rear of boiler	Rear of boiler
Heating sur. of econo.	11,095 sq.ft.	11,448 sq.ft.
Econo. sur. per sq.ft. boiler heating sur.	0.744 sq.ft.	0.763 sq.ft.
Diameter of tubes	2 in. O.D.	2 in. O.D.
Number of tubes	880	212

FUEL

Kind	Natural gas	Oil
Heat value, B.t.u.	1,191 per cu.ft.	18,616 per lb.

BOILER SETTINGS

Distances	
Floor to center line mud drum	13 ft. 1½ in. Stirling; 10 ft. 6 in. Connelly
Floor to center line steam drum	32 ft. 9½ in. Stirling; 32 ft. 9½ in. center drum of Connelly
Front wall to bridge wall	11 ft. 1½ in. Stirling; 11 ft. 6 in. Connelly
Type of settings	Brick, steel encased, ventilated furnace walls and bottom
Construction of setting furnace walls	9 in firebrick, 11 in. air passage; 4 in. insulated casing. Firebrick wall anchored to buckstays by bonding tile, hooks, bolts, and clips
Firebrick, first quality	
212,000 Mizzou brick and tile	A. P. Green Fire Brick Co.
114,000 Walsh XX brick and tile	Walsh Fire Clay Prod. Co.
88,000 Argon brick and tile	The Vitrefrax Co.

MISC. BOILER FITTINGS

Safety valves	Consolidated
Blowoff cocks	Everlasting, geared
Blowoff valves	Yarway, type B
Soot blowers	Diamond "Valve-in-head" in economizers only
Gage glasses	Williams
Water columns	Stets

CHIMNEY

Type	Reinforced concrete supported on building steel
Built by	Weber Chimney Co.
Number	Four
Boilers per stack	Two
Diameter	13 ft. 4 in.
Height above boiler-room floor	126 ft.

OIL STORAGE

Received by	Pipe line
Storage	Four 10,000-bbl. concrete tanks Two 30,000-bbl. steel tanks
Fire protection	Steam smothering lines
Service tanks	Two concrete
Location	Underground
Capacity	3,000-bbl.

OIL-BURNING EQUIPMENT

Fuel oil pumps	Four, 65 g.p.m. screw type
Maker	W. E. Quimby, Inc.
R.p.m.	960
Pressure	250 lb.
Driven by	3—by motors, 1 by turbine
Fuel oil heaters	Four, double, 65 g.p.m.
Maker	C. F. Braun Co.
Temp., oil	275 deg. F.
Press., oil	250 lb.
Press., steam	125 lb.
Burners	Comb. oil and gas
Maker (Connelly boilers)	Peabody Engineering Co.
(Stirling boilers)	Babcock & Wilcox Co.
Auto. fuel-oil control valves	C. J. Tagliabue Mfg. Co.
Burners per boiler	15
Air at maximum capacity	1 in.

FORCED-DRAFT FANS

Manufacturer	Green Fuel Economizer Co.
Type	Radial flow backward curve, blades, double inlet
Driven by	30 hp. 440 volt, var. speed, slip-ring motor
Number per boiler	One
Capacity	30,000 to 60,000 c.f.m.
Static pressure	1 to 2 in.
Speed	285 to 475 r.p.m.

INDUCED-DRAFT FANS

Maker	Green Fuel Economizer Co.
Type	Straight blade, self-cleaning, double-inlet
Driven by	Var. speed, brush-shifting motor
Number per boiler	One
Capacity	48,000 to 110,000 c.f.m. at 450 deg. F.
Static pressure	1½ to 4 in.
Speed	326 to 540 r.p.m.

BOILER-FEED PUMPS

Maker	Worthington Pump & Mcy. Corp. Jeanesville
Number and type	Four 6 in. 5-stage double-suction
Capacity	1,000 g.p.m.
Suction	8 in.
Discharge head	6 in.
Speed	1,105 to 1,460 r.p.m.
Driven by	Three by 250 hp. var. speed slip-ring motors One by 300 hp. West. turb.

DEAERATOR PUMPS

Maker	Byron Jackson Pump Mfg. Co
Number and type	Four, 2-stage double-suction
Capacity	1,000 g.p.m.
Discharge head	165 lb.
Driven by	150 hp. const.-speed ind. motors

EXTRACTION HEATERS

Maker	Griscom-Russell Co.		
Type	Floating head, closed type		
	18th Stage	11th Stage	Gland Steam
Number	2	2	2
Heating surf., sq.ft.	1,950	2,090	735
Passes	4	4	6
Material of tubes	Muntz	Admiralty	Muntz
Water per hour	350,000 lb.	433,500 lb.	408,000 lb.
Temp entering	80 deg. F.	220 deg. F.	188 deg. F.
Temp. leaving	142 deg. F.	307 deg. F.	204 deg. F.
Steam per hr.	14,722 lb.	30,416 lb.	6,500 lb.
Abs. press.	3.64 lb.	70.8 lb.	14.7 lb.

Heat Exchangers:

Maker	Griscom-Russell Co.	
Type	Multiwhirl	
Used for	Extracting heat from 18th and 11th stage heater drip	
	18th Stage	11th Stage
Surface, sq.ft.	67.5	350
Tube material	Muntz	Muntz

TURBO-GENERATORS

Make and number	Two, General Electric Co.
Capacity	Turbine 37,800 kw., main generator 35,000 kw. at 90 per cent P.F., auxiliary generator 2,800 kw. at 70 per cent P. F.
Speed	1,500 r.p.m.
Main generator	3 phase, 50 cycles, 11,000 volts
Aux. generator	3 phase, 50 cycles, 2,300 volts driven by main turbo generator
Exciter (for aux. gen.)	45 kw., 250 volt, on generator

TURBINE

Number of stages 20

Guaranteed performance at 350 lb. pressure, 700 deg. F. and 1½ in. back pressure absolute. No bleeding but includes gland steam leakage.

Load, Kw.	Steam per Kw.-Hr.
20,000	10.25
25,000	9.95
32,000	9.69
35,000	9.90
42,500	10.10

SURFACE CONDENSER

Maker	West. Elec. & Mfg. Co.
Number and type	2 two-pass double-compartment
Tube surface	55,000 sq.ft.
Tube surf. per kw	1.45 sq.ft.
Steam per sq.ft. per hr. (No bleeding)	7.83 lb.
Connection to turbine	Rigid
Supports	Springs
Tube composition	Admiralty (Scovill Mfg. Co.)

DATA ON PRINCIPAL EQUIPMENT IN LONG BEACH STEAM PLANT NO. 2 SOUTHERN CALIFORNIA EDISON COMPANY—Continued

Circulating Pumps:

Number	2 per condenser (West.)
Capacity, one pump running	44,000 g.p.m.
Capacity, two pumps running	70,000 g.p.m.
Speed range	216 to 290 r.p.m.
Driven by	250 hp., 2,200 volt, var. speed, slip-ring ind. motors

Condensate Pumps:

Number	2 per condenser (West.)
Capacity	1,000 g.p.m. (500,000 lb. per hr.)
Total head	155 ft.
Driven by	75 hp., 2,200 volt, motors

Air-Removal Equipment:

Number	2 units per cond. (West.)
Type	Steam jet with surface inter- and after-condenser
Number of elements	2 per unit
Capacity per unit	240 lb. of air per hr.

GENERATOR AIR COOLERS

Maker	General Electric Co.	
Type	Surface	
	Main Gen.	Aux. Gen.
Capacity	110,000 c.f.m.	14,000 c.f.m
Cooling water	Salt	Salt
Cooling water g.p.m.	720	120
Temp. air outlet	104 deg. F.	104 deg. F.
Temp. water inlet	75 deg. F.	75 deg. F.

DEAERATOR

Maker	Cochrane Corp.
Type	2 reboiling type with heating and air separating trays.
Steam pressure	19.5 lb. abs. (ext. from 15th stage)
Capacity (lb. per hr.)	350,000 normal, 400,000 max.
Water temp.	190 deg. F. inlet, 227 deg. F. outlet
Condensing surface	430 sq.ft.
Steam per hour	14,431 lb.

EVAPORATORS

Maker	Bethlehem Shipbuilding Corp. Ltd.
Type and Number	2 two-effect, low-heat level
Capacity	17,500 lb. per hr.
Steam pressure	19.5 lb. abs. ext. from 15th stage
Steam per hour	12,970 lb.
Evaporator-Condenser:	
Type	Straight tube, closed
Number of passes	2
Surface	970 sq.ft.
Evaporator Feed-Water Heater:	
Type	Straight tube, closed, single-pass
Surface	50 sq.ft.

AIR COMPRESSOR

Maker	Ingersoll-Rand Co.
Type	XB with unloader
Capacity	600 cu.ft. free air per min.
Size	17x10x14 in., 185 r.p.m.
Driven by	150 hp. constant-speed ind. motor

EXCITERS FOR MAIN GENERATORS

Maker	General Electric Company	
Number	2 comb. turb. and motor-driven 1 motor-driven	
	Comb. Drive	Motor Drive
Capacity kw	175	350
R.p.m.	1,470	1,000
Voltage	Motor 2,200 a.c. Gen. 250 d.c.	Motor 2,200 a.c Gen. 250 d.c.
Steam pressure	350 lb.	

TURBINE-ROOM CRANE

Maker	Manning, Maxwell & Moore, Inc.
Type	4—motor
Capacity (Tons)	Main hoist—100 Auxiliary hoist—15
Span	64 ft. 9½ in.

SERVICE ELEVATOR

Maker	Otis Elevator Co.
Type (pass. and freight)	Push-button control
Capacity	4,000 lb.
Speed	100 ft. per min.

SCREEN WELL EQUIPMENT

Maker	Chain Belt Co.
Type	"Rex" traveling
Number per screen well	1

OIL COOLERS

Maker	Griscom-Russell Co.
Type and number	Seven, 2 pass, vert., multiwhirl
Used for	Cooling transformer oil
Cooling water required	200 g.p.m.
Temp. of oil entering	140 deg. F.
Temp. of oil leaving	113 deg. F.
Cooling-water temp	77 deg. F.

MISCELLANEOUS PUMPS

Well-Water Pumps:

Maker	Pacific Pump Works
Number and type	Two 2-stage, cent.
Used for	Fresh water to storage tanks
Capacity	500 g.p.m.
Discharge head, ft	165
Driven by	30 hp. const.-speed ind. motors

Salt-Water Low-Service Pumps:

Maker	DeLaval Steam Turbine Co.
Number and type	2 double suction, single-stage, cent
Used for	General salt water low service and emergency transformer and generator air cooler
Capacity	1,500 g.p.m.
Discharge head, Ft	125
Speed	1,450 r.p.m.
Driven by	75 hp. const.-speed ind. motors

Generator and Transformer Cooling Water Pump:

Maker	DeLaval Steam Turbine Co.
Type	Double-suction, single-stage cent.
Used for	Salt water for gen. air coolers and trans. oil cooling
Capacity	1,500 g.p.m.
Number	3
Discharge head	65 ft.
Driven by	40 hp. const.-speed ind. motor

Distilled-Water Pumps:

Maker	Byron Jackson Pump Mfg. Co.
Type and number	2 single-stage, centrifugal
Used for	Pumping makeup distilled water from storage to surge tank
Capacity	900 g.p.m.
Driven by	40 hp. const.-speed ind. motor

Sump Pumps:

Maker	Worthington Pump & Mach. Corp.
Type and number	2 vert., single-stage, cent.
Used for	Dirty water sump
Capacity	300 g.p.m.
Discharge head, ft	20
Speed	960 r.p.m.
Driven by	5 hp. cons.-speed ind. motors

Evaporator Blowoff pumps:

Maker	Nash Engineering Company
Type and number	2 Hytor cent. vacuum pump
Used for	Pumping evaporator blow-down to drainage system
Capacity	10 g.p.m.
Discharge head	5 ft. with 20 in. vacuum on suction
Speed	1,440 r.p.m.
Driven by	Cons.-speed ind. motors

Transformer Oil Cooling Pumps:

Maker	DeLaval Steam Turbine Co.
Type	Double-suction, single-stage, cent.
Used for	Pumping oil through trans. oil coolers
Number	7
Capacity	100 g.p.m.
Discharge head, ft	67
Speed	1,450 r.p.m.
Driven by	5 hp. const.-speed ind. motors.

Evaporator Drip Pumps:

Maker	Byron Jackson Pump Mfg. Co.
Type	2-stage, hotwell type, cent.
Used for	Pumping drip from evaporators into station condensate system
Capacity	75 g.p.m.
Discharge head, ft	147
Driven by	10 hp. const.-speed ind. motor

18th-Stage Heater Drip Pumps:

Maker	Byron Jackson Pump Mfg. Co.
Type and number	Four 2-stage, hotwell type, cent.
Used for	Pumping drip from 18th stage heater into condensate system
Capacity	75 g.p.m.
Discharge head, ft	147
Driven by	10 hp. const.-speed ind. motor

Priming-System Pump:

Maker	Nash Engineering Co.
Type and number	2 Hytor cent. vacuum pump
Used for	Maintaining 20 in. vac. on priming system header. Connected to all important cent. pumps in station not under positive head.
Capacity	58 cu.ft. free air per min.
Speed	960 r.p.m.
Suction head	20 in. mercury
Driven by	7½ hp. const.-speed ind. motor

Lubricating-Oil Pump:

Maker	Blackmer Rotary Pump Co.
Type and number	One rotary
Used for	Gen. lub. oil transfer service
Capacity	100 g.p.m.
Discharge head, ft	50
Speed	Motor, 960 r.p.m.; pump, 250 r.p.m.

Fire Pump:

Maker	DeLaval Steam Turbine Co.
Type and number	1 Double-suction, single-stage, cent.
Capacity	2,000 g.p.m.
Discharge head	206 ft.
Speed	1,450 r.p.m.
Driven by	150 hp. const.-speed ind. motor

TANKS

Raw fresh water (storage)	2 concrete, 5,500 gal. each; 2 steel, 3,200 gal. each
Distilled water (surge)	2 steel, 7,000 gal. each
Distilled water (storage)	1 concrete, 62,000 gal. under boiler basement

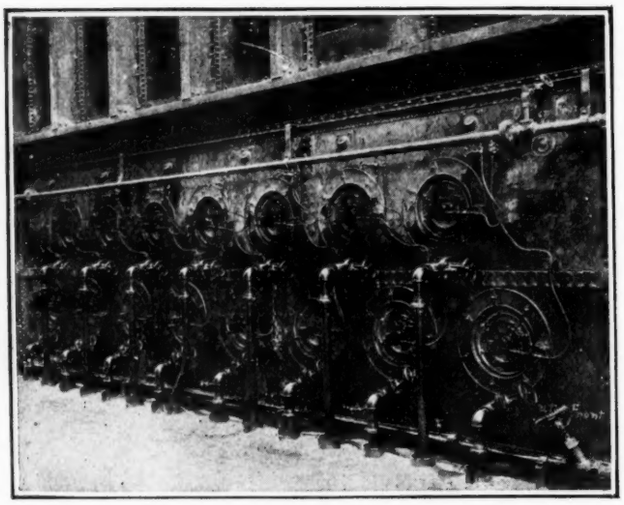


Fig. 6—Furnace front showing combination oil and gas burners

feature are in the boiler room for the information of the boiler-room operating forces.

Automatic load indicators are provided in the turbine and boiler rooms of both plants for indicating the total load being carried on each respective plant at the time. These indicators are also provided with demand pointers manually controlled by the switchboard operator for giving an indication of the anticipated demand on either plant.

A 2,300-volt truck-type switchboard equipped with a sectionalized ring bus is provided for switching and distributing the energy from the auxiliary generators. The switchboard is in the boiler-room basement, but the control for the generator and ring bus sectionalizing circuit breakers, together with the instruments and relays, are located at the main control board in the switchhouse. Manual control at the truck board is provided for all auxiliary power distribution feeders throughout the station. Overload relays on the individual motor control panels are connected to trip the auxiliary power feeder circuit breaker at the truck board.

All motors 50 hp. and above are operated at 2,200 volts, and all motors under 50 hp. are operated at 440 volts through duplicate banks of transformers which step down the energy and distribute it through two 9-panel switchboards. A duplicate 440-volt distribution system is provided, connected to double-throw switches at each motor-starting equipment for connecting the motor to either bank of 440-volt transformers.

All constant-speed motors with the exception of the one driving the 330-kw. exciter are of the double squirrel-cage type arranged for starting directly across the line. All variable-speed motors are provided with starting equipment which automatically restarts the motors upon restoration of the supply and brings the motors up to the speed at which they were set at the time the supply failed.

A lead acid storage battery of 60 cells, having a normal eight-hour discharge rate of 100 amperes, is provided for emergency lighting and the operation of all electrically controlled switching equipment, this capacity being sufficient to carry the maximum emergency load for a period of one-half hour to a final voltage of 1.75 volts per cell.

DATA ON PRINCIPAL EQUIPMENT IN LONG BEACH STEAM PLANT NO. 2 SOUTHERN CALIFORNIA EDISON COMPANY—Concluded

PIPING SYSTEMS

Circulating-Water System:	
Gate valves	Pittsburgh Valve, Fdy. & Cons. Co.
Pipe and fittings	Local foundries
Expansion joints	U. S. Rubber Co.
High-Pressure Steam System:	
Gate valves	Pittsburgh Valve, Fdy. & Cons. Co.
Globe valves	Edward Valve & Mfg. Co.
Boiler non-return valves	Schutte & Koerting Co.
Pipe and fittings	Pittsburgh Valve, Fdy. & Con. Co.
Holly drip system	Russell B. Hobson
Boiler-Feed System:	
Gate valves	Crane Co.
Globe valves	Edward Valve & Mfg. Co.
Check valves	Crane Co.
Pipe	Grinnell Co., Inc.
Fittings	Reading Valve & Fittings Co.
Atmospheric Relief System:	
Valve	Atwood & Morrill Co.
C. I. pipe	Local foundries
Welded steel plate pipe	Lacy Mfg. Co.
Fuel-Oil Lines:	
High-press. gate valves	Crane Co.
Globe valves	Edward Valve & Mfg. Co.
Bolts and Gaskets:	
High-press. steam	
Studs	"Mayari" Steel Bethlehem Steel Co.
Gaskets	"Sargol" Joint
Boiler Feed:	
Standard Machine Bolts	Square head, Hex. nuts
Gaskets	Part Sargol joints Part Goodyearite
High Press. Oil	
Standard Machine Bolts	Square head, hex. nuts
Gaskets	Garlock No. 902
Miscellaneous:	
Boiler drum-head valves	Edward Valve & Mfg. Co.
Safety valves	Consolidated
High-pressure trap	Squires
Heat insulating material	Asbestos Mfg. Co. of California using Johns-Manville spec. high-temp. covering on main and aux. superheated steam piping and 85 per cent magnesia on the balance

MISCELLANEOUS

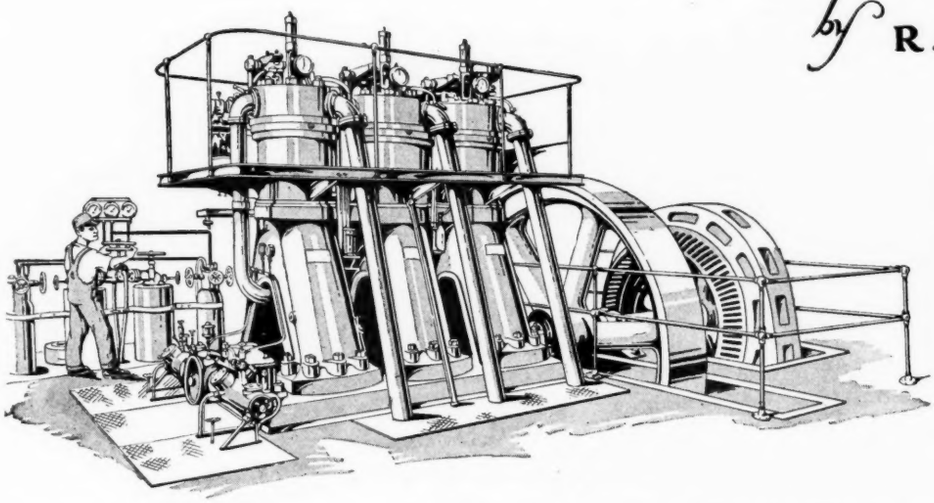
Boiler Feed Pump Regulators:	
Motor-driven pumps	Ruggles-Klingemann Mfg. Co.
Turbine-driven pump	Fisher Governor Co.
"Flowrite" Cond. Tube nozzles	Albert E. Mace Co.
Cond. tube packing	Dura Metallic Packing Co.
Electroytic prot. for cond.	Kirkaldy Engineering Co.
Valve control	Payne Dean Ltd.
Smoke detector equip.	Walter Kidde & Co., Inc.
Feed water regulators	Williams Gage Co.
Water columns	Williams Gage Co.
Water-col. illuminators	National Co.
Turb. lub. oil systems	S. F. Bowser & Co., Inc.
Lub. oil purifier	DeLaval Separator Co.
Condensate test scales	Howe Scale Co.
Fuel-oil test scales	The Fairbanks Co.

STATION INSTRUMENTS

Boiler-control meters	Bailey Meter Co.
Boiler draft gages	Bailey Meter Co.
Mono duplex CO_2 and CO meters	C. J. Tagliabue Mfg. Co.
Fuel-oil meters	Bassler Thermos. controlled Liquid Meter Co.
Natural gas meters	Builders Iron Foundry
Master steam gage	Ashton Valve Co.
Oil-storage tank gages	Pneumercator Co.
Boiler-feed meters	Builders Iron Foundry
Steam-flow meters	General Electric Co.
Cond. cir. water meters	Cochrane Corp.
Salinometer	Leeds & Northrup Co.
Evaporator feed-water meters	Neptune Meter Co.
Watchman's clock system	Newman
Load indicators	West. Elec. & Mfg. Co.
Indicating press. gages	Ashcroft Mfg. Co. The Foxboro Co., Inc.
Indicating thermometers	Taylor Instrument Co. The Foxboro Co., Inc.
Mercury col. vac. gages	Taylor Instrument Co.
Recording press. gages	The Foxboro Co., Inc.
Recording thermometers	The Foxboro Co., Inc.
Recording vac. gages	The Foxboro Co., Inc.
Recording liquid level gages	Bristol Co.
Gage boards	Bangor, Pa., Electrical Slate Los Angeles Marble and Tile Co.

OPERATION OF DIESEL ENGINES

by R. Hildebrand *



How to Choose a Suitable Lubricating Oil and When to Apply It

SINCE lubrication is one of the main factors on which the successful operation of a Diesel engine depends, the conditions essential for proper lubrication should be provided and suitable lubricants should be used.

It does not pay to buy inferior lubricants, nor does it pay to use a lubrication system that does not keep the lubricant in good condition for a reasonable length of time. The owner of a power plant should not expect cheap and reliable power from his Diesel engine unless he maintains a good lubrication system for it.

Nearly every well-established and reliable refiner manufactures lubricants that possess the necessary qualities. However, the physical characteristics of an oil do not always furnish a proof that it possesses the desired lubricating qualities and it is best to buy none but well-known brands of Diesel oils.

Oil Characteristics

Usually, three different kinds of lubricants are used: One for the power cylinder; one for the crankcase system, lubricating the crankshaft bearings, crankpins and wristpins; and one for the compressor. For the power cylinders and the crankcase pure mineral oils, uncompounded with animal or vegetable oils, and neutral filtered as a final process of manufacture, should be used. The lubricants for the compressor are either pure mineral oils or mineral oils compounded with vegetable oils. All oils used should stand the following emulsion test: Mix one ounce of oil and one ounce of distilled water, heat to 180 deg. F., and then shake violently for five minutes, after which the mixture should stand and separate completely during one hour.

Nothing but a well-suited lubricant for the power cylinders will prove successful. Unsuitable oils will cause carbon deposits and sticky piston rings, resulting in blowing pistons and consequently contamination of the crankcase oil with carbon. Some years ago I visited a Diesel power plant where the bad effects of improper cylinder lubrication were strikingly evident. A hot crankpin box caused a shutdown, and an inspection revealed a carbon deposit about $\frac{3}{8}$ in. thick all over the crankcase. The plant had run out of Diesel cylinder oil and had used ordinary red engine oil instead, which formed carbon, caused the rings to gum up, the piston to blow, and thus fouling the crankcase oil, caused a hotbox.

It is a wrong idea to think that an inferior oil copiously applied to the cylinders will do as well as a good oil. In fact it is poor policy to feed more lubricating oil, even of the best grade, to the power cylinder than is absolutely necessary. Too much oil will gum up the piston rings and will cause oil to drip from the liners. This oil having been subjected to heat, is contaminated by carbon, which thus finds its way into the crankcase. This should be avoided as much as possible.

If the liner is free from scale and well cooled, and if a suitable lubricating oil is used, about 3 to 4 drops per feed per minute should be enough for each cylinder. Two-stroke-cycle engines need a little more oil, as a part of the lubricant finds its way into the exhaust ports and is thus lost. Some manufacturers of four-stroke-cycle engines do not provide for any special lubrication for the power cylinders, but depend entirely on the splashing in the crankcase to lubricate the pistons and liners. This splashing is considerable in a high-speed engine equipped with a force-feed oiling system.

Regulating Oil Feed

The best and most dependable way for the operator to judge the amount of lubricating oil needed for the cylinders is as follows: Immediately after stopping the engine he should look at the cylinder from below and run his hand over the surface of the liner to determine whether or not it is coated with a film of oil. In addition it is important to inspect the upper, or hot end of the cylinder liner, which should always be done when an exhaust or inlet valve is removed, or when the cylinder head is lifted off. If this inspection shows the liner to be dry, or insufficiently lubricated, at its upper end, more oil should be supplied, but if the examination shows that the lubrication is more than actually needed, the feed should be slightly decreased. The oil feeds to each cylinder should be regulated and adjusted independently of one another, as the different cylinders frequently require different rates of feed.

*Chief Engineer, Diesel Division, Fulton Iron Works Co.

For this reason it is not enough to inspect only one liner and then regulate the lubrication of all cylinders on a basis of the requirements of the one. Investigation will frequently reveal that some of the cylinders are better lubricated than others.

To repeat, it is not difficult to lubricate the cylinders properly provided the engine is well taken care of, and this includes, first of all, effective cooling of the liner. In addition to proper cooling of the liner, there are certain points that should not be lost sight of, as they materially affect the cylinder lubrication. In case the load of the engine is not evenly distributed, some of the cylinders are underloaded and others overloaded. The overloaded cylinders naturally attain an undesirable temperature from the viewpoint of lubrication. Afterburning, indicated by a smoky exhaust, also causes higher and undesirable liner temperatures because the flame lasts during the greater part of the working stroke, exposing to fire the whole oil film adhering to the liner. In this case the oil film is likely to be destroyed, resulting in insufficient cylinder lubrication and excessive liner wear. Smoky exhaust should not be tolerated for this and many other reasons.

Keep the Oil Clean

There is no need to mention why dirt and grit should be kept out of the oil. Fuel oil dilutes the crankcase oil, reducing its qualities and adding sulphur to the lubricant. For this reason all joints of the fuel pipes should be kept tight and care should be taken to prevent fuel oil from mixing with the lubricant. Water, entering the crankcase, will form an emulsion with the oil. Inasmuch as a mixture of water and lubricating oil

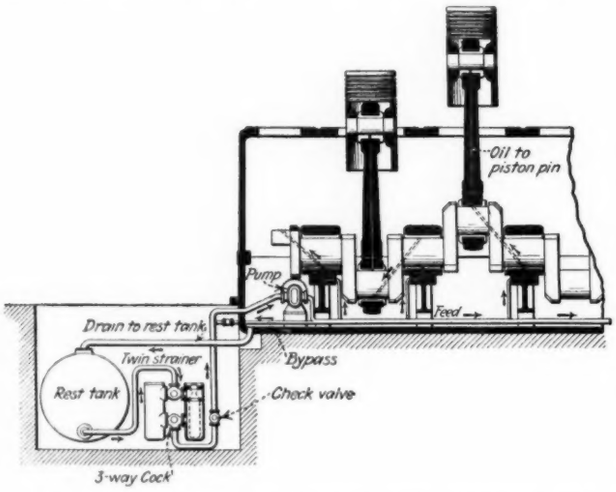


Fig. 1—Pressure oiling system with strainers and settling tank

has not the same lubricating quality as a pure lubricant, water should be prevented from entering the crankcase and a lubricating oil that readily separates from water should be used. Carbon entering the crankcase as a result of excessive cylinder lubrication and blowing pistons is an undesirable substance as it accentuates the tendency of the oil to form sludge or muck with mulsified water.

All lubricating oil forms sludge when used in an engine of any kind. The sludge formation seems to depend a great deal on the acid content of the oil, which increases with the length of service. Particularly, if the lubricating oil is heated and brought in intimate contact with air, it begins to oxidize or to acidify. For this reason it is highly desirable to keep the crankcase temperature as low as possible and to avoid undue oil splashing therein. A good lubricant, one well filtered through Fuller's earth, will have a low acid content and will acidify slower than one having a comparatively high percentage of acid. The acid saponifies with the water absorbed by the lubricant and thus forms a sub-

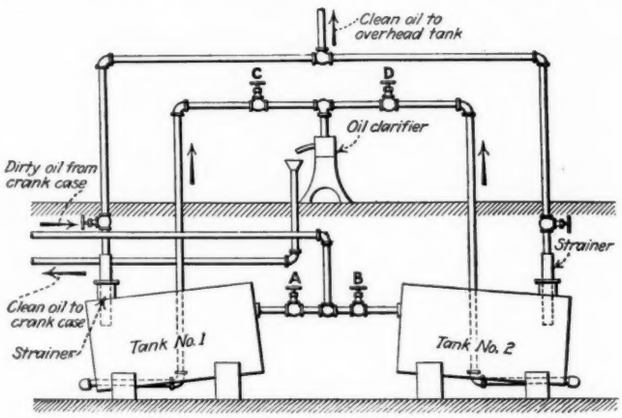


Fig. 2—Purifying system used with gravity feed oiling

stance resembling a wax. This wax, or sludge, can be seen floating in the oil when looking through a thin body of oil lying on a plate of glass with a white background below it. Since sludge formation can hardly be prevented, it is obvious that something must be done to purify the oil, otherwise bearing difficulties will follow. Fortunately, it is easy to keep the lubricating oil in good condition provided suitable equipment is at hand.

Filters for Oiling Systems

If the engine is equipped with a sight-feed gravity system the manufacturer of the engine generally furnishes a filter for the crankcase oil. In this system the amount of oil circulated per hour is small and can be conveniently filtered without making the filter excessively large. These filters will, to a certain extent, retain the impurities contained in the oil and will prevent their passing into the bearings.

Engines, having force feed oiling systems are generally not equipped with filters to clear the oil continuously, as here the amount of oil circulated per hour is so great that filtering would be inconvenient. The oiling system of these engines consists in most cases of nothing else but a circulating pump, a twin oil strainer, and an oil cooler. In this system the oil circulates continuously without coming to a rest. Thus the impurities contained in the oil have little chance to settle out unless the oil is frequently removed and filtered.

Some lubricating systems require a cooler for recooling the oil after it is strained or filtered and before it reaches the engine. High-speed engines with limited bearing surface require cold lubricating oil in order to keep the bearings cool. Force-feed lubricating systems, even for low-speed engines, frequently require an oil cooler because the total oil volume contained in the system is very small and rapidly circulated. This leaves the oil insufficient time to dissipate the heat that it absorbs while passing through the bearings. Thus the oil heats up unduly and becomes unfit for bearing

lubrication unless it is cooled. Sight-feed gravity systems using filters and overhead tank generally need no oil coolers. Here the system contains several barrels of oil which circulates slowly, giving the oil sufficient time to cool before it reaches the engine.

When the oil system is drained and before it is filled again, the frames, crankcase, circulating pumps, pipes, sump tanks, filters, overhead tanks and oil coolers (if the engine is equipped with same) should be cleaned thoroughly. Some of these parts must be flushed out with kerosene; some may be cleaned with hot water. For wiping use rags, not waste.

The writer suggests that the engineer frequently test the crankcase oil relative to its acid content. This is easily accomplished. Take a small bottle and fill it half full with equal parts of hot water and oil to be

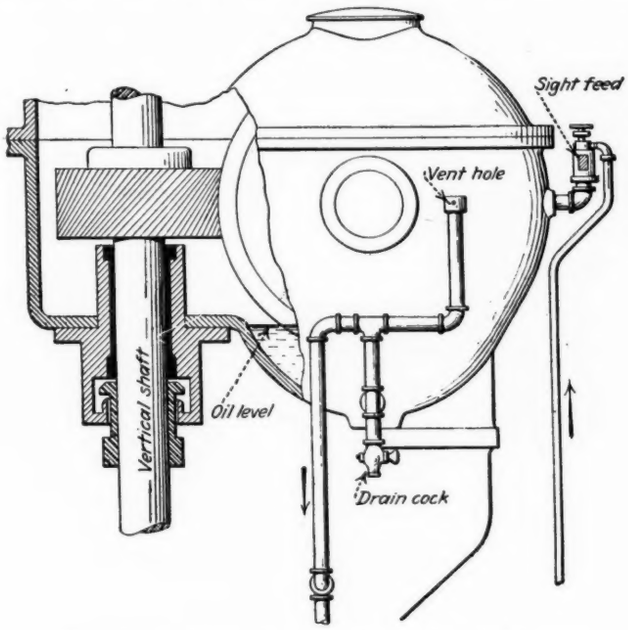


Fig. 3—Method of lubricating camshaft gear

tested. Shake violently for about ten minutes and then allow the oil to separate from the water. Pour off the oil and placing a small piece of blue litmus paper in the water, observe how quickly and how intensely the paper changes color from blue to red. The quicker and the more intense this change is, the greater is the acid content. If the oil contains too much acid some of the oil should be withdrawn from the system and replaced by a new supply. How often this should be done will depend on the quality of the new oil and on many other conditions, and so no rule can be laid down. However, to mention some definite figure, the writer suggests that this acid test be made every two weeks and the oil be sweetened every two months.

The engineer should observe closely the temperatures of the bearings. Hang a thermometer in the crankcase and place another in intimate contact with the bearing shell. If necessary provide a drilling in the bearing cap to accommodate the thermometer. The difference between the temperatures of the bearing and the crankcase indicates how successfully the bearing is lubricated. To touch a bearing with the hand is not a reliable guide in determining the bearing temperature. The hand can generally stand only 110 to 120 deg. F., while in some engines the bearing temperatures run up to 130 or even 140 deg. By keeping record of the exact bearing temperature, the engineer can at all times know the condition of the bearings and note any change in the operating condition.

A well-designed compressor kept in good working order will not cause lubricating difficulties, provided a suitable grade of lubricant is used and provided the compressor is well cooled. Heavy liner wear and sticking of piston rings will result if the cylinders are allowed to accumulate scale. It is also essential that the valve chests and intercoolers be well cooled, so that the air is brought back to approximately atmospheric temperature before it reaches the next higher stage.

If the air is not well cooled after it leaves one stage, it will heat up much more in the following stage. The lubricating oil carried along by the air will also heat, carbonize and gum up the valves. Gummed valves will not function properly and will leak, which makes conditions worse. If the valves are not tight, part of the air will leak back. The friction caused thereby will heat the air abnormally, resulting in an increased gumming of the valves and air passages.

It is obvious that the less lubricating oil the air contains the less will be the tendency of the valves to gum. For this reason the lubricant used for the compressor should vaporize as little as possible at the existing temperatures. Generally, one or two drops of lubricating oil per minute and per stage is ample. The amount of lubricating oil consumed by the compressor is very small so that the cost per gallon need not be considered. For this reason nothing but the very best lubricant for the compressor should be bought and used.

Oiling Camshaft Gears

The lubrication of the gears driving the camshaft sometimes causes difficulties. However, if they are made of suitable material, well machined, carefully aligned and properly lubricated, they will not wear excessively. But if the lubrication of the gears is wanting, they have to be replaced at frequent intervals, which is costly.

Two successful methods are used for lubricating these gears. Either they run in a compartment filled with a heavy gear compound or they are running in an oil bath through which oil of the same quality as used for the crankshaft circulates continuously.

The first-mentioned method of lubricating the gears gives satisfaction only if the gear compartment is oiltight and if the gear compound is renewed frequently. However, if the gear compartment is not oiltight, permitting the gear compound to work out, due to centrifugal force or otherwise, the gears will run dry and will cut. Since the metal worn off the gear remains in the lubricant, this wearing process is hastened. The same will be the case if dirt can enter the gear compartment.

For this reason the writer prefers the method where the gear is running in an oil bath which is continuously renewed by circulation. Fig. 3 shows such an oiling system. A continuous stream of new oil is supplied from the circulating system. The oil enters the gear compartment through a sight feed glass and leaves the compartment at its extreme bottom, whereby dirt and grit are carried along by the oil. The oil, after leaving the gear compartment, rises in a short standpipe which is vented on top. Then the oil passes through a drain pipe into the crankcase.

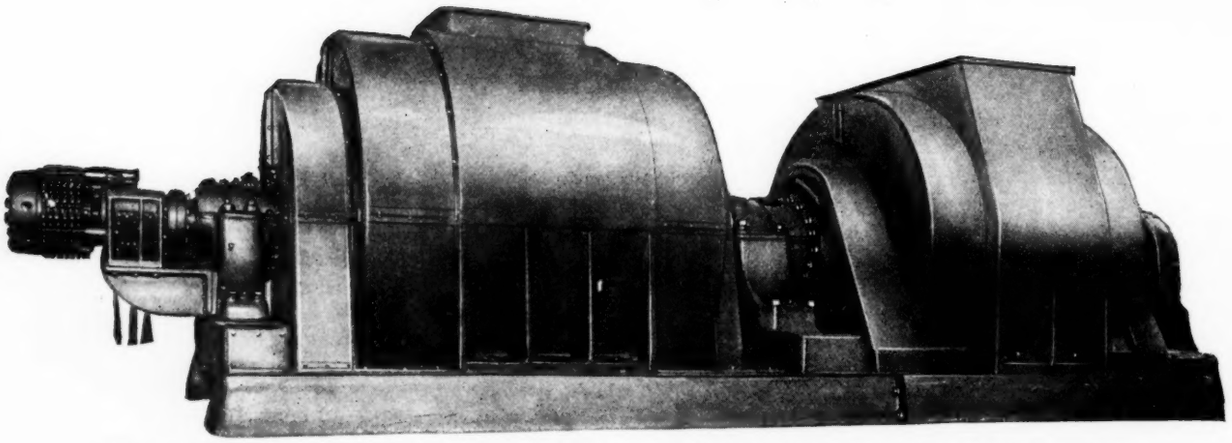


Fig. 1—Frequency converter rated at 6,000 kw. to tie together a 60- and a 25-cycle system

Scherbius Controlled Induction Synchronous Frequency Converter

Frequency Changer Sets Designed So That They Will Operate With a Maximum Variation of 9 Per Cent in the Frequency of the Two Systems They Tie Together

By R. E. GREENE
Engineer, Central-Station Department, General Electric Company

IT IS frequently desirable to tie together two systems of different frequencies. Such ties are made by frequency converters, and these usually have been of the synchronous-synchronous type. This type of frequency converter consists of a synchronous motor of one system frequency direct connected to and driving a synchronous generator of the other system frequency, such as a 25-cycle motor driving a 60-cycle generator.

The synchronous-synchronous type of frequency converter has limitations that prevent its use as a tie between some systems. It forms a rigid tie and requires a fixed relation between the speeds—that is, the frequencies—of the two systems. Obviously, this type of set cannot be used if the frequencies of the two systems vary so that this relationship is not maintained. In itself, this type of set has no adjustment by which the load transfer between the system can be controlled. The amount and direction of load transferred must be controlled by adjustment of governors of prime movers of the systems, which operation may not be convenient. In making the tie, the speed of this type of set cannot be adjusted for synchronizing and the system speeds must be changed until the set is in synchronism. Again, this may not be convenient.

Two Machines Installed

The General Electric Co. has developed a type of frequency converter in which the foregoing operating limitations are overcome. This is known as the Scherbius controlled induction-synchronous type of set. It requires no fixed relation between the two system frequencies, the amount and direction of load transferred is controlled by an adjustment of the set itself, and the speed of the set can be changed for synchronizing.

Two sets of this type, each rated 6,000 kw. at 80 per cent power factor, are being installed by the Rochester (N. Y.) Gas & Electric Corp., to form a tie between the Rochester 60-cycle system and the Niagara, Lockport & Ontario 25-cycle system. These sets are designed to provide for a total variation of 9 per cent in the two system frequencies. Thus, with the frequency of one system constant, the other may vary 9 per cent, and with both system frequencies varying, the total variation can be 9 per cent.

Each set consists of a 7,500-kva. 11,000-volt three-phase 60-cycle synchronous generator directly connected to an 8,500-hp. 11,000-volt three-phase 25-cycle wound-rotor induction motor. Regulating equipment is provided for the latter, consisting of a separate 300-kva. regulating set, an ohmic-drop exciter direct connected to the main set and two small rheostats and control transformers. If the 60-cycle system frequency is constant, the sets will operate at a constant speed of 720 r.p.m. Depending on the frequency of the 25-cycle system, the induction machine will operate at above or below synchronism. The Scherbius-type control equipment for the latter machine controls the load transferred.

Speed Control of Induction Motors

Fig. 1 shows the main set with ohmic-drop exciter for control of the induction machine on the left and direct-current exciter for the field of the synchronous machine on the right. Fig. 2 shows a close-up view

of the ohmic-drop exciter as it is mounted on the outboard bearing of the induction machine, and Fig. 3 is the regulating set.

Any method of controlling the speed or load of a wound-rotor induction motor requires a means of controlling the flow of secondary current. In the commonly used resistor method this is attained by changing the total impedance of the secondary circuit by inserting a variable external resistance. This method is wasteful

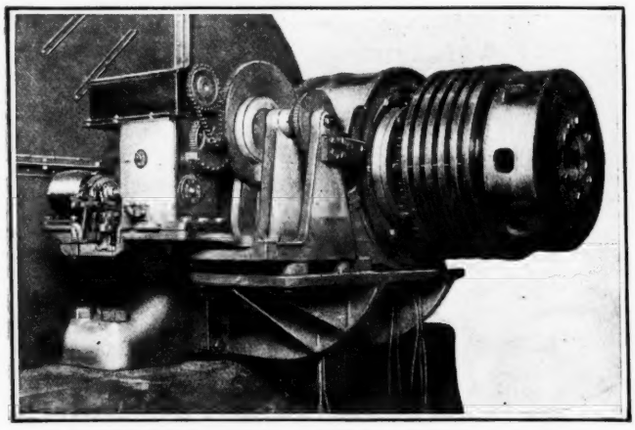


Fig. 2—Ohmic-drop exciter mounted on shaft of motor of frequency-changer set

because of the losses in the resistors. Furthermore, adjustments can be made at speeds below synchronism only.

The principles involved in the Scherbius method are essentially the same as in the resistor method. In the latter there is a voltage drop of slip frequency in the resistors which opposes the flow of secondary current. This requires that the slip, and hence the speed of the motor, adjust itself to generate sufficient secondary voltage to force the current required for the load through the secondary circuit. In the Scherbius method the secondary current is controlled by inserting, in the secondary circuit, a voltage of slip frequency whose magnitude and phase angle is controlled by the operator.

This voltage of slip frequency is obtained from the commutator of the regulating motor of the regulating set, which is of the polyphase commutator type, Fig. 4. It has shunt fields excited at slip frequency from the ohmic-drop exciter. Three sets of brushes on its commutator, properly spaced, furnish three-phase voltage, which is applied to the slip ring of the main induction motor. As the excitation of the fields is at slip frequency, so is the voltage obtained on the commutator of slip frequency, and its amount and phase angle are controlled through the shunt fields. The regulating motor is direct connected to an ordinary induction motor which is connected to the main lines, usually through transformers.

Control Permits Operating Main Motor Above or Below Synchronism

As previously stated, the control permits operation of the main motor above or below synchronous speed. Below synchronism the voltage of the regulating motor opposes flow of secondary current and secondary power that would be lost in the resistor method if transferred through the regulating set back into the line. Above synchronism the regulating-motor voltage forces the current through the secondary circuit and power is taken from the main lines and furnished through the regulating set to the rotor of the main motor.

The ohmic-drop exciter, Fig. 4, which is connected to the main set, is the "nerve center" of the control. It must supply excitation at exactly slip frequency to the fields of the regulating motor in order that this machine generate voltage at slip frequency for connection in the main-motor secondary circuit. It must also provide means for controlling the amount and phase angle of the excitation in order that the speed, load and power factor of the main motor may be controlled.

The ohmic-drop exciter is similar in construction to the armature of a rotary converter. Power is supplied to this exciter through slip rings from the main lines through suitable transformers, and power for exciting the fields of the regulating motor is taken from the exciter's commutator through three sets of brushes, each set spaced 120 electrical degrees. The ohmic-drop exciter has no field winding; instead, it is enclosed by a shell of magnetic material. The voltage applied to the slip rings creates a magnetic field which revolves at synchronous speed with respect to the ohmic-drop exciter. Its direction of rotation is opposite to the mechanical rotation of the exciter. The frequency of the voltage taken from the commutator is determined by the speed of rotation of the magnetic field in space.

Operation of Ohmic-Drop Exciter

With the main motor running at exactly synchronous speed, the field of the ohmic-drop exciter is stationary in space and direct current is taken from its commutation. Under this condition the regulating motor furnishes direct current to the main motor secondary as required for the operation of the latter at synchronous speed. With the main motor running above or below synchronous speed, the magnetic field revolves in space

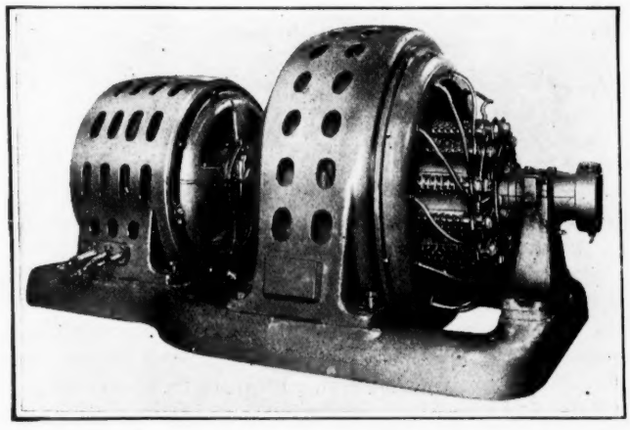


Fig. 3—Double-range regulating set for load and frequency adjustment

at a speed that is the difference between its speed with respect to the ohmic-drop exciter's rotor and the mechanical speed; that is, at speed of slip. Thus the voltage on the commutator of the ohmic-drop exciter, and thence on the commutator of the regulating motor, is always of the same frequency as the secondary voltage of the main motor.

Fig. 5 shows connections of the speed field of the regulating motor to the commutator of the ohmic-drop exciter. Each phase of this field is connected across two sets of brushes on the commutator. The voltage of

excitation of this field, and hence the speed or load of the main induction motor, is varied by means of a brush-shifting device on the ohmic-drop exciter which moves the brushes to include more or less commutator bars between brushes for each phase. This brush shifting mechanism is motor operated, Fig. 2, and the load or speed is easily controlled from the board by the operator.

The Scherbius type of control permits a certain amount of power-factor correction on the main induction motor. For the Rochester sets the control is

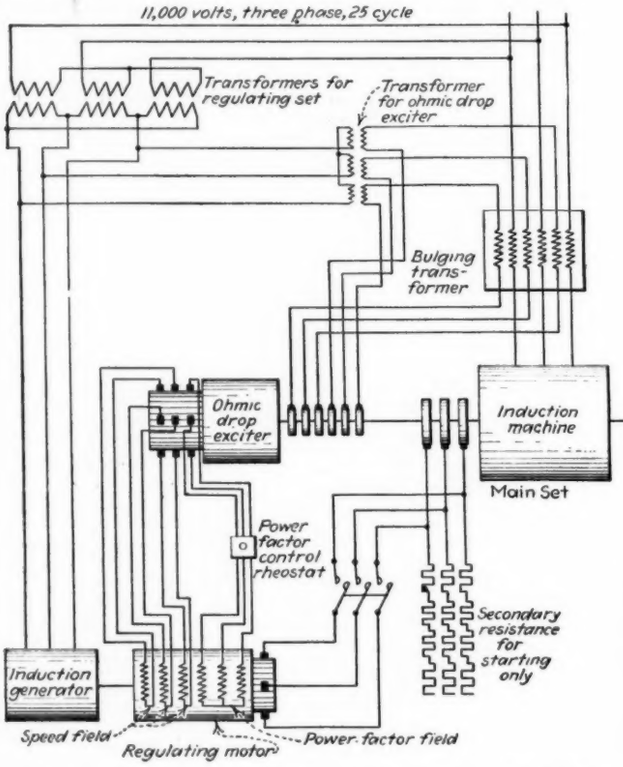


Fig. 4—Diagram of main connections for Scherbius controlled frequency-changer set

designed automatically to hold within certain limits the wattless kva. taken by the motor operating over its entire load and frequency range. These limits are such that the motor will operate at full load over its entire frequency range at very close to unity power factor. The control of the power factor requires a means of adjusting the phase angle of the voltage of the regulating motor. This is obtained by controlling the phase angle of the exciting voltage obtained from the commutator of the ohmic-drop exciter.

The phase angle of the exciting voltage for the fields of the regulating motor is changed by means of a movement of the ohmic-drop exciter brushes and by means of the bulging transformer shown in Fig. 4. Voltage is supplied to the rings of the ohmic-drop exciter from the ohmic-drop exciter transformers through the secondaries of the bulging transformers whose voltage is proportional to the load. The secondaries of the bulging transformers are so connected that their voltages add to the main transformer voltages at an angle, and thence the phase of the voltage applied to the exciter rings is shifted automatically with the load.

The movement of the brush-shifting device on the ohmic-drop exciter not only shifts the brushes to include more or less commutator bars between the brushes, but it also shifts the axis of the brushes in Fig. 5 to change the phase angle of the voltage. Through the operation of the bulging transformer and proper movement of brushes, the reactive kva. of the motor is automatically controlled, as previously mentioned.

Further manual control of the power factor is obtained through the power-factor field of the regulating motor. It is excited from a separate set of brushes on the ohmic-drop exciter so located that the excitation

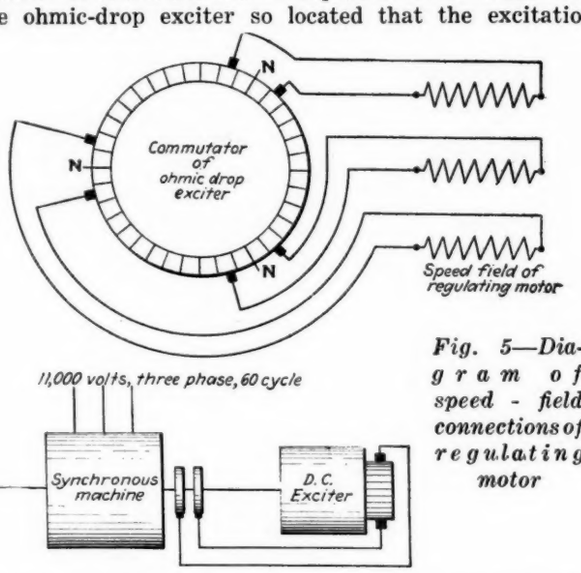


Fig. 5—Diagram of speed-field connections of regulating motor

of the power-factor field is at a suitable angle to that of the main or speed field. By adjustment of the power-factor field through the power-factor rheostat, the phase angle of the regulating-motor voltage, and hence the power factor of the main motor, may be controlled.

The main set is started from the 25-cycle induction motor end by means of secondary starting resistors. When the main set is up to speed and the regulating set is started, the secondary of the main motor is connected to the regulating motor and the secondary starting resistors are cut out. The latter are used for starting only.

When the set is connected to both systems, control of load is through control of the motor of the brush-shifting mechanism of the ohmic-drop exciter. This control may be through a control switch or through a contact-making wattmeter which will hold a definite load on the set with frequency of systems varying.

Although it is a seeming paradox, it is true that the best cylinder packing for an oil engine is no packing at all. It seems to be the idea of the average engineer that he must use a thick packing in order to seal the joint securely. Even though it may be demonstrated that, theoretically, the more compressible the packing is the greater the elongation of the studs before "blowing" will occur, in actual practice a thick packing should be avoided. In designs where the head and cylinder flanges are faced straight across, the best possible packing is a thin sheet of copper. This sheet should be annealed and made perfectly smooth and straight. The flange surfaces should be cleaned and, if necessary, smoothed up with emery cloth. The copper gasket, which should rest inside the studs to keep it in place, will maintain a tight seal of the joint.

Manufacturer Has His Own Superpower System

A Factory System Where Separate Power Plants Were Interconnected Electrically—Exhaust Steam Used For Process Heating

ON HIS return from a southern trip one of the members of the Power staff was recounting the impressions he had gained to a group of fellow engineers.

"I suppose," queried one of the group, "that you were interested most in the vast system of interconnection carried out by a number of the Southern power companies?"

"The hydro-electric systems in that part of the country have certainly carried out the idea of interchange of power, but the most interesting system of interconnection I encountered was not carried on by a public service company, but by a single manufacturing company."

"Tell us about this one-man system," chimed in several.

"Well," said the editor, finding a comfortable position in his chair, "on my way back from Louisiana I stopped at a town where there was an immense tobacco works. It is unusual in many ways, but especially from an engineering viewpoint in that the buildings are not in a single group but instead are located in five separate parts of the town."

"That's sheer inefficiency," exclaimed one of the engineers who had been brought up in the belief that efficiency is obtainable only by consolidating activities into a single large mill.

"That was my first thought," retorted the editor, "until the engineer explained that this represented the highest development of the manufacturing principle.

"Remember that each group of buildings is a complete tobacco factory. In each one are made chewing tobacco, smoking tobacco and cigarettes. Suppose a fire should start in one of the mills? Even if that group were entirely destroyed, the output of products would continue, although at a diminished rate. In other words the management of that company felt that while there might be a slight increase in operating expenses, the avoidance of complete shutdown was worth millions. The plan was in effect a form of fire insurance.

"It was found that the group factory scheme really lowered the operating cost. You see each group was competing with the others for lower costs, and as a consequence the factories have unit costs below those in competing plants. The system was carried out to the extent that each group had a boiler house, for, you understand, a lot of steam is used for curing the tobacco and live steam at 100 lb. pressure was used in the driers. Power was purchased from the public utility company at an average cost of 1 cent per kilowatt-hour.

"The drawback to the entire scheme was the problem of the power plants. At first glance a centralized power plant seemed the proper solution. With such a layout, instead of using live steam for the driers and purchasing electric power, all the power needed could be generated in the central engine room and the exhaust steam sent through underground pipe lines to the factory groups. The drawback was that the investment in the pipe lines would be enormous and the losses heavy. In addition the idea of self-contained factory groups would be destroyed, since a damage in the central power plant would shut down the whole works."

"But where is the wonderful interconnecting power system?" broke in another of the editor's friends.

"In this way," continued the editor, quite undisturbed, "the chief engineer evolved the plan of using the four boiler plants and by installing engine-generator units, of discontinuing the purchase of electric power.

"The necessary steps were taken, and one at a time the four groups were provided with engine rooms, the exhaust steam replacing the former live steam to the processes. Corliss engines were used since the steam consumption of this type would about coincide with the exhaust-steam needs. In one plant a duplex engine was installed on account of lack of room space to put in a single-cylinder unit.

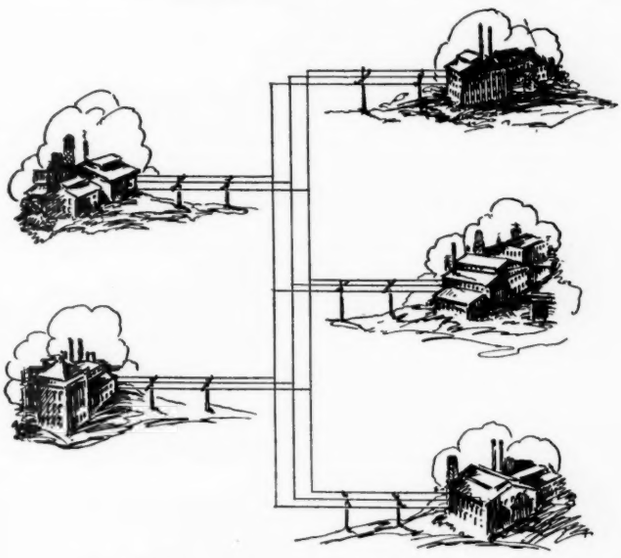


Fig. 1—Transmission line interconnects five groups of factories

"The decrease in the combined cost of process steam and electric energy made itself evident; the new system was a success. The engineer, however, could not feel as enthusiastic as did the owners. He could not ignore the cloud of steam blowing out the atmospheric relief in some of the plants, for you see, the demand for steam did not always coincide with the process demand. In fact, as a rule live steam was being used in one plant to make up the deficiency in the exhaust, while in another plant the relief was blowing wide open for the reason that the mechanical load far exceeded the exhaust demand.

"Naturally, the engineer began to study the idea of hooking the plants together electrically. The more this was studied the more feasible it looked. Consequently, a 2,300-volt line was put in, interconnecting the four engine rooms, and in the fifth plant, which was in process of construction, a 1,250-kw. bleeder turbine was installed, together with surface condenser, cooling tower, water-tube boilers, superheaters and the like. Here is a sketch I made of the layout." (See Fig. 1.) "If, say, in plant No. 1 the mechanical load exceeds the exhaust-steam demand, the engineers in this plant carry only enough of this load to keep the back pressure up to the regular one of 7½ lb. per sq.in. gage. The remainder of the mechanical load is carried by juice coming in from one of the other plants where the steam demand is greater than the power requirements. When I was there one plant was using only 200 kw. although the engine was putting 1,000 kw. onto the switchboard, the factory requiring a large amount of steam for curing and other process purposes.

"The bleeder turbine is the balance wheel of the system. The steam needed in this group is bled off at 7 lb. gage, while the rest of the steam continues on its way through the turbine into the condenser. The condenser cooling water is put over a double-fan forced-

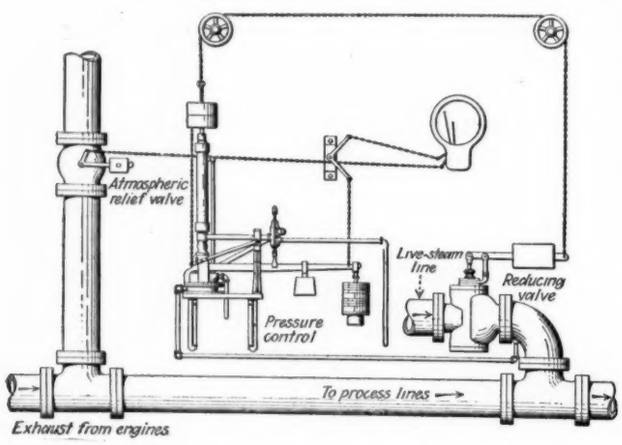


Fig. 2—Method of regulating and recording the pressure in the heating main

draft cooling tower, the makeup water being drawn from the city mains. If at any time the balance between the power loads and the exhaust-steam demands is disturbed, so that, for example, the power load increases, the engineers at each plant regulate the voltage of the units in that plant so that the engine will not carry more load than needed to give the exhaust steam needed."

"But where does this extra power come from?" someone asked.

"From the bleeder turbine. Just as soon as the voltages in the several engine rooms drop, the turbine picks up more of the total load since its voltage is held up above that of the engine plants. As before enough steam is bled off to meet the demand for this factory group and the rest goes in through the low-pressure part of the turbine, delivering a kilowatt at about 13 lb. of steam."

"That's pretty low for a medium-sized turbine," interposed one of the engineers.

"But," was the counter, "the boilers in the turbine plant are inclined-tube water-tubes and not only operate at 200-lb. pressure, but in addition the steam is superheated 150 deg."

"It seems to me," again broke in the engineer, "that it would be difficult to balance the system so that the exhaust from all the engines would be enough at all times to supply the process demand. It is not every day that one sees a plant layout where this is possible in ordinary operation."

"Things are not that rosy," was the reply. "The system can be balanced as to power demands by the turbine, but at times the exhaust from one of the units is not enough. At such times the group needing the extra steam must take live steam through a reducing valve. This reducing valve is automatic in action, opening whenever the pressure in the process steam line drops below 7 lb. gage. The chief engineer found that the usual reducing valves were not satisfactory, as they were either wide open or entirely shut. Consequently, he made use of the diaphragm and levers of a damper regulator and found that the lever would open the reducing valve at a pressure change of but a few ounces.

"To prevent any plant from exhausting through the atmosphere relief while the pressure reducing valve was open, the chief ran a lever from the relief valve and one from the reducing valve, connecting both to pencil movements of a recording dial. In this way the minutes or hours either is open are shown on the paper record, and hard luck befalls the operator whose record shows both open at once. Fig. 2 here is a sketch of the arrangement."

"That protects the individual plant in a way, but what keeps it from carrying too much of the load, so that the engine exhausts to the atmosphere?" asked one of the listeners.

"The recording watt-hour meter in each plant shows the engine load of that plant, and this compared with the record showing opening of the relief valve is a check on the operators.

"So excellent is the operation of this superpower system that its savings over the cost of buying an equal amount of electric power and supplying live steam to the factories was over $45,000 a year after deducting overhead charges in the additional investment. In many respects the boiler operation is not modern, hand firing being followed, but the average evaporation is 10 lb. per pound of Pocahontas coal. The firemen are negroes, while the oilers and watch engineers are white.

"Now," continued the editor, "why cannot such a system be applied to a number of factories under different ownerships? In almost every industrial community there will be found some mill, such as a dye works requiring a lot of hot water but little power; another, such as a furniture factory or textile mill requiring both process steam and power; still another which may need much power but little exhaust steam or hot water. By hooking up such mills in an intelligent way, the total cost of power or heat would be reduced to an astonishing extent.

"Unfortunately, it is seldom done. In fact at another place I visited, a company operated a knit-underwear mill that used purchased energy, while two miles away it had a cotton mill and dyehouse that was equipped with engines operating with atmospheric exhaust, while live steam was used in the dye vats. There is ample condensing water available, and by installing bleeder turbines in the cotton mill and running a transmission line to the underwear factory, a big saving in power would be possible."

Unaflow vs. Compound Duoflow Engines*

By ROBERT CRAMER
Consulting Engineer, Milwaukee, Wis.

ALL the means for increasing the efficiency adopted by steam-engine designers during the development of the steam engine, are a more or less complete compliance with the second law of thermodynamics, which, for practical purposes, may be stated as follows: All heat must be absorbed by the heat carrier at as high a temperature as possible, and all rejection of heat must take place at as low a temperature as possible. Under this heading comes the adoption of higher steam pressure, low condenser pressure and the use of superheat.

It was recognized early in a practical way that there were certain limitations to the carrying out of theoretical requirements. As an example, the use of high steam pressure and the consequent large ratio of expansion might be cited. Early in the development of steam engines it was found that large ratios of expansion in a single cylinder would not bring about the increase of efficiency expected. The cause was cylinder condensation, and this was traced directly to the large temperature difference existing in a single cylinder between the entering steam and that of the steam exhausted from the cylinder after expansion to a low pressure.

To reduce the condensation loss, compounding was adopted, the expansion being carried out in two or more cylinders so as to reduce the loss due to cylinder condensation in each in proportion to the corresponding reduction of the temperature difference.

Limiting Conditions Necessitate Compromise

The unaflow engine reduces cylinder condensation by other means. After the expansion has taken place, the steam is exhausted through a port which the piston over-travels at the end of the stroke. It is evident that the piston again must cross the port when it has moved but a short distance on the return stroke. The clearance is proportioned in such a way that the pressure at the end of the return stroke is equal or nearly equal to the admission pressure. The result is that the incoming new steam meets steam of approximately the same temperature as its own, so that no part of the incoming steam is condensed.

There is another feature of this arrangement that is important. In the compound type of steam engine the steam is admitted and is discharged through the same port or through two ports, both of which are in the head end of the cylinder. The exhaust steam is swept through the length of the cylinder, and as it is cool and the cylinder is warm, it has a chilling effect on the cylinder walls. In the unaflow engine the steam remains practically stationary in the cylinder and there is no such action and no chilling. It seems that the unaflow engine can do in one cylinder what other engines do in two or more.

All this seems ideal for steam-engine economy, but there are other influences which make complete realization of the ideal impossible. In the first place, should expansion be carried to the level of the back pressure, then the compression curve would retrace the expansion curve and the engine would not do any work at all. This means that in practical unaflow engine design a compromise must be reached, in such a way that the gain resulting from unaflow action is more than sufficient to offset the loss due to incomplete expansion. In reaching this compromise it must be borne in mind that the greater the ratio of expansion the larger and more costly the engine will be for a given rating.

Another important source of loss in the unaflow engine, especially when it is working non-condensing, is the large clearance. It is easily seen that an engine compressing steam for nearly the full length of the stroke, when this compression begins with atmospheric pressure, must have a large clearance. In the unaflow engine this is provided by special pockets in the head or in a hollowed out piston.

It is for these reasons that the modern unaflow engine is a compromise in more ways than one. To meet the conflicting requirements of this engine several methods have been proposed, but the method that seems to be the most promising and the one that probably will be adopted universally in the future is that of shortening the compression. Many engines are built today which have auxiliary exhaust valves which are kept open when the exhaust stroke begins and which, according to proper adjustment, the valve gear closes at any desired point between the beginning and the end of the stroke. This arrangement makes it possible to reduce the clearance in non-condensing engines and still reach the admission pressure at the end of the compression; on the other hand, it reintroduces some sweeping action of the exhaust steam and consequent chilling. It has been found in practice that a good practical and economical compromise can be worked out, and many engines of this type are now in operation.

Unaflow Has Wide Load Range

It has often been stated that for any given condition of steam pressure, superheat and exhaust pressure, compound engines and, even more so, multiple-expansion engines can be designed to give a better economy than any unaflow engine for the same conditions. This is true, but the compound or multiple-expansion engine, while more economical for the load for which it was designed, will not be so for loads above and below this best load. In other words, the unaflow engine has a characteristic flat economy curve, whereas the economy curve of the compound or multiple-expansion engine rises whenever the load goes above or below the best.

Also, if a given engine is used under varying load conditions, the average economy of the unaflow engine will be better usually than the average economy of the compound or multiple-expansion engine, although the best performance of the latter is better than the best of the unaflow.

These different characteristics of these engines have brought about the prominence of each in its particular field. The unaflow engine today is used to the greatest extent in small industrial installations and especially in factory drives where power and heat requirements are combined. Variable loads are common in installations of this kind, and the fact that exhaust steam can be used for heating either during the whole or a part of the year, makes the use of a steam engine more economical than the buying of power even at low rates. On the other hand, whenever loads are steady, the

*Abstract of paper read before Chicago Section of the American Society of Mechanical Engineers, Jan. 14, 1925.

unaflow engine has not replaced successfully the compound and multiple-expansion engines. A typical example of this is found in marine installations, especially in smaller freight boats, where loads are uniform excepting for the small percentage of time used in maneuvering. The advantages which the unaflow engine possesses for marine work on account of the fact that all the cylinders in multiple-cylinder engines are alike, have not been able to secure for it this field, where fuel economy is of prime importance.

Discussion

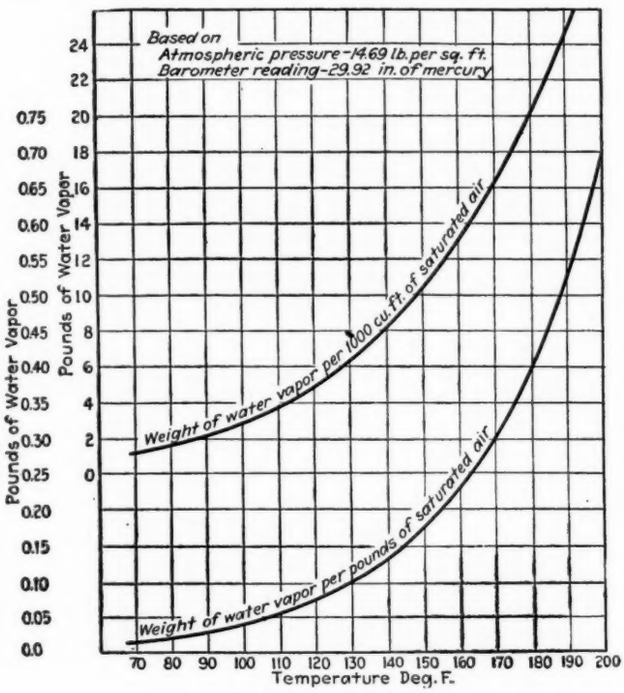
Following the presentation of the paper Professor Philbrick, chairman of the session, asked Mr. Cramer to repeat briefly just the field that the unaflow engine had found entirely for itself. In reply Mr. Cramer stated that in looking around the plants of industrial concerns with which he came in contact in his capacity of consulting engineer, he had seen many fine old Corliss engines giving good service. In nine cases out of ten, however, when an engine goes into an industrial plant it is a unaflow. Corliss engines are still sold and also compound engines, but only on rare occasions. The engine that is outstanding in the industrial field is the unaflow, and if it is desired to include a more recent development, the Prosser engine. The reason for the eminence of the unaflow engine in the industrial field is simply that it shows good economy under great variation of load and when operating either condensing or non-condensing, if it is built to take care of those varied conditions. Another outstanding reason is that this type of engine can be used to good advantage during the heating season operating non-condensing, and the same engine under summer conditions, operating condensing, shows good economy when there is no call for the exhaust steam. Also it is cheaper to build than a compound engine.

W. L. Abbott referred to the investigation made some years ago by the Prime Movers' Committee of the N. E. L. A. on the subject of unaflow engines. From the best information that could be had at that time, the unaflow engine could not compete with the compound engine over a considerable range of load, that is, in the ordinary working range, particularly in the fairly steady work in electric light production, or in any other steady load. He was interested to know wherein the higher efficiency of the unaflow engine was obtained. Mr. Cramer admitted that for a given load the compound engine which had been worked out with all the refinements known to the art, could, for given conditions, be made superior in steam economy to the unaflow. In most cases, however, that engine would cost a good deal more than the corresponding unaflow engine.

Powdered Coal as a Steam Boiler Fuel

In an address before the Providence Engineering Society, Jan. 20, Henry Kreisinger said that the furnace is the heart of the boiler plant. Its efficiency is in the hands of the operator, whereas the efficiency of the engine room in service is largely in the hands of the turbine or engine manufacturer. The best results from burning pulverized coal are obtained when from 15,000 to 30,000 B.t.u. are generated in the furnace per cubic foot of combustion space per hour. If the attempt is made to exceed this, incomplete combustion results or else the flames may gouge into the furnace walls and destroy them. If the walls are carried too far into the furnace, gouging will follow. A pulverized-fuel furnace must have a certain minimum flame or gas path, and this extends beyond the path of visible incandescence. This flame travel is necessary to consume the fixed carbon of the fuel. As the volatile matter increases, the flame lengthens. With low volatile coal and high fixed carbon the flame is short.

Pulverized coal makes for high efficiency because it can be burned with low excess air, which means operation at higher temperatures. The ash tends to cause erosion of the furnace walls, and this must be overcome. One method is to have a relatively thin furnace wall and to pass cool air outside it through an air space between the inner and outer walls. A furnace lining 9 in. thick may be used and from 60 to 70 per cent of the air required for combustion passed

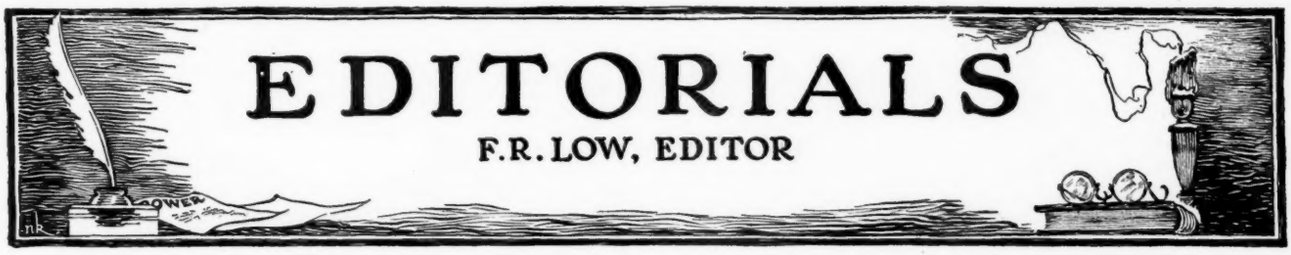


Water vapor carried by air

through this channel between the walls and thence into the furnace. If the slag from the ash drips down the wall it does little harm, but if it runs down it tends to carry away the lining.

It is important to protect bins and conveyors from sudden cooling and cold winds, lest moisture be deposited from condensation. A strong blast of outside air into a bin may cause trouble. The speaker stated that recently a plant with outside temperature 25 deg. below zero had the ventilators open. In using flue-gas coal driers it is never advisable to bring the gas temperature below 150 deg. F. Otherwise if the gas holds much moisture there is danger of part of this water vapor condensing on the drier. A chart giving the weight of water vapor that can be held by air at various temperatures was shown and is reproduced here.

Water heaters, fuel-oil heaters and in fact all heat exchangers should be taken out of service and thoroughly cleaned at regular intervals, the length of such intervals depending upon the nature and severity of the service.



The Creative Mind in Engineering

PERHAPS the most important single factor in the development of science and engineering has been the creative or inventive faculty of the human mind. It is wonderful how the mind can play with known facts much as a child plays with his blocks, trying this arrangement and that until some new combination is achieved. While most marked in the great inventors, this creative faculty exists to some extent in all worthwhile minds and is capable of considerable development by exercise.

When an individual possesses this faculty in a marked degree, but lacks the background of knowledge generally necessary for the production of new ideas of real value, or the will and fixity of purpose which alone can insure their translation into practical realities, he is called an idle dreamer and is considered a misfit in such a practical pursuit as engineering. But when creative imagination is armed with knowledge, guided by inflexible will and censored by plenty of horse sense, its possessor need never apologize; his services will be at a premium.

Another Investigation

HAVING acquired the habit of inquisition, Congress has now directed its attention to the so-called "power trust." By a vote of fifty-five to twenty-five the Senate has passed a resolution directing the Federal Trade Commission to investigate the General Electric Company and its stockholders. The resolution appears to have been founded, not upon a definite charge that the law is being violated, but rather upon allegations that this company, through its subsidiaries and interlocking directorates, is exercising a monopoly over the production and distribution of electric energy as well as the manufacture, sale and distribution of electrical equipment.

That the General Electric Company has had large interests, directly and indirectly, in many power companies has long been a matter of common knowledge; in fact no attempt has been made to conceal it. That in itself, however, would not constitute a violation of the law. Presumably, if the company had been making illegal use of such control this should have been easily ascertainable under the powers already vested in the Federal Trade Commission.

This is essentially an age of big business. It has been asserted that ninety per cent of our productive wealth is attributable to this source, and the effect on our prosperity, through increased employment and a better standard of living, is immeasurable. Notwithstanding this, there is a very considerable element in our population that is ever ready to attach suspicion to business because it is big. This may be due to the demagogue's appeal to the emotions being more effective than the business man's appeal to reason. In view of this it is reassuring to read the comments on the proposed investigation by Owen D. Young, chairman of the Board of the General Electric Company and the man that did most to work out the Dawes Plan, that "burdensome and expensive as it is to a business, it is better than unfounded charges based on misinformation."

While there is always a danger that investigations of this character may exert a disquieting effect on business, temporarily at least, in the present case the reaction may be wholesome. It may again become apparent, in the words of Roosevelt, "that there are good and bad big business."

Inexcusable Obstructions

AS TO a national policy for the prevention of the exhaustion of our fuel supply, there has been practically nothing done. Judging from the way our water-power development program has been handled by government agencies, one might think that it was promoted to prevent development of this self-perpetuating power supply and to exhaust our fuel as fast as possible. It took Congress twenty years to decide upon a national policy for water-power development. That the principles as promulgated in the Water Power Act of 1920 are sound is shown by the fact that applications have been made to the Federal Water Power Commission for the development of about twenty-five million horsepower.

Notwithstanding this great demand to develop water power, there is today a falling off in the new construction, when compared with that during the two previous years—not because capital is not available to carry on this work nor because there is no market for the power after it is produced, but very largely on account of governments and the states having failed to adjust their selfish interests. Another factor is that in other cases it is not known how the power resources of certain rivers should be developed, and when an application is made for development, there is a long delay in passing upon the proposed program. Furthermore, Congress has failed to provide the Federal Water Power Commission with the necessary funds to perform its functions properly. The most serious indictment of Congress in this respect is that the administration of the Federal Water Power Act, even to carry on studies of rivers and power developments, could be made self-sustaining from the annual charges paid by the licensees under the Act, if the Commission were allowed to use these fees for carrying on its work, but it is still being hampered after four and one-half years of effort.

There is nothing to be gained by holding up water-power development, except to find out what should have been known by the government long ago. On the other hand, one million horsepower-years produced by

coal that could have been produced by water means the needless fuel loss equivalent to about twelve million tons of coal. The waterwheel manufacturers have made good with their part of the program and have produced turbines having efficiencies well over ninety per cent—as high as can ever be expected and with a high degree of reliability. On this score there is nothing to hold up an extensive development of our water power.

Regulation of Superheat

DIFFICULTIES are being experienced in some of the new stations in maintaining uniformity of superheat. Where the steam temperature leaving the superheater is normally seven hundred degrees Fahrenheit or higher, any surges in superheat are likely to be of serious moment, for it is generally assumed that the strength of steel pipe falls off rapidly when heated above seven hundred and fifty degrees.

Increased superheat may be due to higher excess air than normal, to broken or improper baffling or to secondary combustion in the superheater portion of the boiler. These contingencies may occur at any time in plant operation, and the question has arisen as to how they may be met and how superheat may be maintained constant at such times.

A method that is being used to some extent for regulating superheat is to install two superheaters, one a convection type located in the usual position above the first pass of the boiler and the second, in series with the first, a radiation type placed in the furnace. With increasing load the convection type gives increasing superheat, while the radiation type produces less superheat, the aim being to produce as nearly as possible a constant superheat at all loads. Experience with the radiation type, however, has been too limited to form a basis for definite conclusions especially as to its location in the furnace. Moreover, the conditions with powdered coal are different from those with stokers, owing to the smaller amount of excess air and consequent higher temperatures.

Several other methods have been proposed, some of which are of questionable feasibility. Most of these embody a plan for mixing saturated steam with the superheated steam leaving the boiler to temper the superheat to the desired amount. While this would seem to be an entirely satisfactory proceeding, it is subject to serious defects. In the first place it is not an easy matter to insure perfect mixing of the saturated and superheated steam even when both are in the same pipe, owing to the difference of densities and to stratification. The second objection is that such bypa sing of saturated steam around the superheater elements themselves only tends to aggravate the conditions in the superheater. With such bypassing, the tubes of the superheater would then have a lesser amount of steam to heat and, thus becoming hotter, would superheat this smaller amount of steam to still higher temperatures. It is conceivable that such a system might allow the superheater tubes to become dangerously overheated.

What is really needed in these tubes when high superheat occurs is a greater rather than a lesser flow of saturated steam. Where can this additional steam be secured? Obviously, not from the boiler itself, for all the steam being generated is already flowing through the superheater. It has frequently been observed that moisture in wet steam entering the superheater will lower the superheat a considerable amount. This has led to a suggested method of regulating superheat:

If a spray of pure water could be admitted into the steam entering the superheater under the control of a thermostatic valve regulated by the temperature leaving the superheater, it should be possible to regulate the superheater within close limits regardless of the fluctuating conditions within the setting. This moisture entering the superheater tubes would act like wet steam and would tend to reduce superheat when high temperatures occur. It virtually makes the superheater partly evaporative surface and, although objectionable if impure water from the boiler is used, it should insure the life of the superheater against overheating. While practicable, many engineers will condemn this method on account of its complexity and the possibility of failure to function properly. Nevertheless, it is worthy of discussion.

A Yardstick for Power-Plant Performance

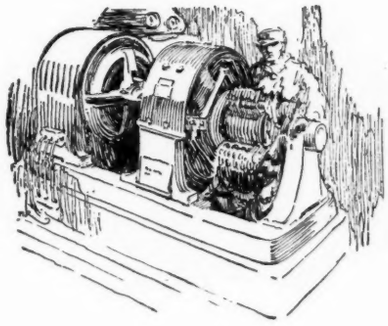
HOW shall "top-notch efficiency" be judged in the average power plant? There are the manufacturers' ratings and the guaranteed efficiencies and efficiencies of individual pieces of apparatus as obtained on acceptance tests, but these do not mean much, especially where the personnel and apparatus for making the tests and determinations are lacking. There are, of course, the theoretical efficiencies, as based upon the thermodynamic cycle, coal analyses, etc. Equipment is required not only to make the tests, but to compute them. In practice they mean little to the average plant.

So the engineer, realizing the shortcomings of his plant, the limitations of himself and the short-sighted indifference of his employer, leaves well enough alone and gropes blindly along in the face of discouragement and lack of support by the men "higher up." There is no yardstick or goal to which he can strive, and lacking a goal, he fails to reach it.

This question of guaranteed or theoretical efficiencies is a real barrier, standing in the way of lower power costs in many plants. It is, perhaps, the major reason that the boiler-room bonus has not found wide usage. By tending to prevent the power-plant force from being paid for results and to mask creditable work, it at once increases the difficulties and counteracts the incentive. What is wanted is a yardstick for measuring power-plant performance—one that can be applied universally with reasonable accuracy and is simple enough to be put to use in the majority of plants.

The papers tell of an air dynamo invented by Herr Bilau, of Germany. From the scanty reports available it may be gathered that this is a scientifically designed windmill with generator attached. A marked improvement in windmill efficiency, if it has been attained as claimed, it is a step toward the practical utilization of wind power, but the parallel problem of energy storage in a truly economic manner still awaits its Napoleon. Undoubtedly, the invention of suitable methods of energy storage would put the question of wind power in an entirely new light. Of course many methods of storing energy are now available: The storage battery, the elevated reservoir, compressed air. The difficulties are in the main financial rather than mechanical. In a word the first cost is too high per kilowatt-hour of storage capacity.

Practical Ideas from Practical Men

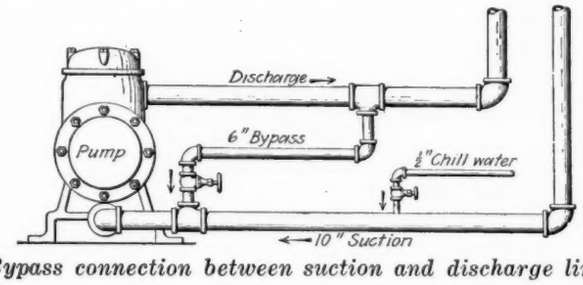


WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. Three prominent operating engineers have been invited to act as judges. The winners will be announced the succeeding month.

Bypass Improves Operation of Vacuum Pump

Although the use of a bypass between the suction and discharge lines of a wet vacuum pump may be familiar to many readers of *Power*, I have never seen it explained in print, so I am passing it along for what it may be worth.

Our plant supplies the light, heat and power for a number of buildings, the largest of which has about



Bypass connection between suction and discharge lines

1,000 radiators. Each radiator is equipped with an air trap, many of which are frequently found dead or blowing through. With a steam pressure in the main line of 1 or 2 lb. we could not obtain more than 5 to 6 in. of vacuum in zero weather or 3 to 4 in. in milder weather, and the heating was unsatisfactory at all times.

After studying the trouble for some time, we decided to try bypassing some of the water discharged by the pump back to the suction. Accordingly, a bypass was connected between the suction and discharge line, as shown in the illustration. This improved the operation of the pump considerably, for we can now maintain 10 to 15 in. vacuum and secure satisfactory heating results. Also, with only ¼ lb. steam pressure in the main line and with the pump running much slower than formerly, or with any rate of flow from 30,000 to 120,000 lb. of steam, we get good results without using any chill water.

We have also installed a bypass on the pump used on our mixed-type heating system, consisting of wet and dry vacuum returns with equally improved results.

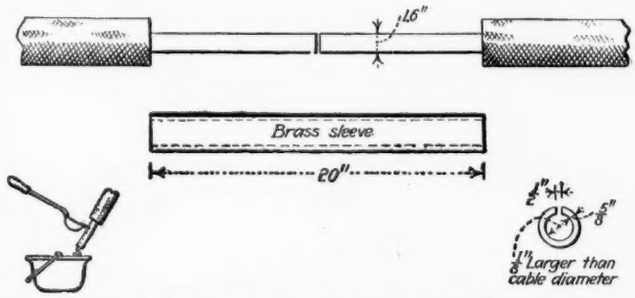
It would appear that the improvement in the operation of the pump is due to its working at full suction capacity with every stroke, regardless of the quantity and temperature of the return water.

St. Louis, Mo. F. H. ALLEN.

Low-Resistance Cable Joints

When electrical generators operate in multiple, especially high-speed generators with interpoles, the question of resistance in cables and equalizers is often a critical matter. On account of some work that had been carried on beneath a power-house floor, it was necessary to cut through several cables of 2,000,000-circ.mils area. The electrical engineer of the plant was much disturbed at the cables' being cut and cited especially that it would be impossible to make a joint with a resistance as low as that of the original cable.

In order to prove to the engineer that his theories were groundless, soldered-sleeve joints were made up with parts as indicated in the figure. Long brass sleeves were procured with dimensions approximately as shown. The cables were then thoroughly tinned, as at the left of the figure. Tinning was produced by pouring from a pot of melted solder, and after a cable reached the proper tinning point, it would conduct the solder internally very much like a pipe; that is, solder would flow along the interior of the cable owing to the



Slotted brass sleeve for soldered cable joints

tinning and would not drop off the cable except where it left at the end.

After tinning the inside of each brass sleeve, it was assembled over cables and the entire connection made by pouring solder through a slot left in the top.

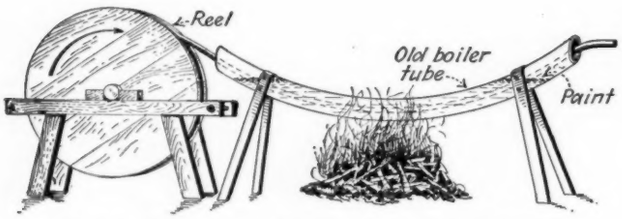
When the job was finished and the installation placed in operation, a test was made with thermometers on the copper sleeves of the joints and also in other places on the main cores of the cables. Observation showed that the joints under heavily loaded conditions ran several degrees cooler than the original cables themselves. This proved that the joint resistance was appreciably lower than that of the original cable.

Jeannette, Pa. G. H. WHITE.

Simple Method of Applying Protective Coating to Crane Cable

Some time ago, while employed at a large industrial plant, I was given the job of applying a coating of paint to the crane cables. As the paint or compound that was to be used was very viscous and the weather cold, I decided to use the method shown in the illustration.

An old boiler tube was cut off the required length and then bent on a long radius and supported by legs as



Paint was applied by drawing cable through a curved tube

shown. After pouring in a little more than enough paint to fill the belly of the tube, the temperature of the paint was raised sufficient to make it flow freely, by building a slow fire below the tube. When the desired temperature was reached, the cable was drawn through the tube.

By this simple process a uniform coating was obtained with a minimum of paint. Care should be taken, however, not to overheat the paint, as this may not only injure the protective properties of the paint, but also the hemp core of the cable. G. T. WHITE.

Portsmouth, Ohio.

How to Save Money in the Refrigerating Plant

At this time of the year most refrigerating engineers are overhauling their plants and making preparations for another busy season; a great many of them are looking for some simple way to keep down the condensing pressure during the hot weather.

I have found that a comparatively small amount of cooling surface used as a de-superheater or precooler will not only lower the condensing pressure from 15 to 40 lb., but if placed between the compressor and the oil trap, will make the oil trap much more efficient. This is owing to the fact that the cooling of the discharge gases will cause the lighter portions of the lubricating oil to condense, and they will then be collected by the oil trap instead of being carried over into the condenser.

Any kind of cooling surface works well, whether it is a plain atmospheric coil, a double-pipe condenser, a shell-and-tube condenser or some home-made contraption. Neither is it necessary to be particular about cooling water. Of course a large amount of low-temperature water is desirable, but I know of one plant where the overflow from the compressor jackets is being used to good advantage in a shell-and-tube condenser. In fact in this case the condensing pressure has been reduced 30 lb. This allows them to operate with their old boiler plant, where otherwise it looked as if it would be necessary to install new boilers, on account of the working pressure having been reduced by the boiler inspector to a point where it was impossible to operate to full capacity any longer. This plant has reduced its coal consumption from 18 to 16 tons per day.

In a motor-driven ice plant the installation of an atmospheric condenser 20 ft. long, 8 pipes high and 4 stands wide is saving over $200 a month in the power bill alone, besides keeping a great deal of oil out of the system.

Another large motor-driven plant is using a shell-and-tube condenser to heat water for thawing the air pipes out of the blocks of ice and to heat water for the dip tank. The gas bill for heating water used to run close to $100 a month, which saving alone would warrant the investment in the condenser. In addition there is a saving in power that will pay for the condenser in less than one year.

Here is a chance for any engineer to save money for his employer and earn an increase in salary, which is always welcome.

It may be the means of relieving the strain on some part of the plant which is showing signs of old age and thus enable the plant to get by for a few more years without the expenditure of large sums of money for replacements. B. C. WEAVER.

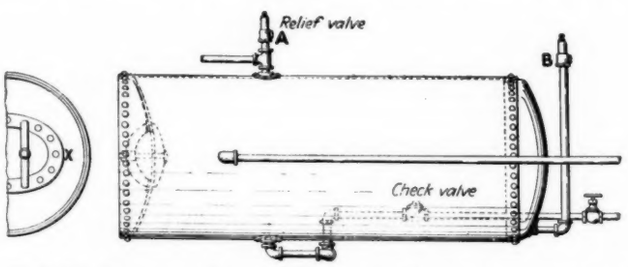
Napa, Calif.

The Value of a Relief Valve

For the purpose of heating water in a certain building a heater was installed consisting of a horizontal cylindrical tank with bumped and dished heads and a steam coil inside. There is an elliptical manhole in the concave head with a reinforcing ring riveted on the outside. The heater is equipped with a relief valve which was located at the point *A*.

The valve was taken off to be repaired and was considered not worth repairing, so a new one was ordered. Instead of replacing the old valve until the new one arrived, the heater was put into commission without a relief valve.

After a couple of weeks it was noticed that the concave head was deformed, being bulged out at the point



Relief valve was changed from position A to position B to eliminate scaling

X. As it was not known whether the deformation was the result of a shock or the gradual result of overpressure, the deformation was checked up, and in a few days was found to be getting worse. A search for the cause of the trouble revealed the check valve behind the heater, its presence never having been suspected.

The relief valve had been removed several times for regrinding and it was always noticed that it was badly scaled. To eliminate the scaling, it was changed to the position *B* so that there would be no hot water in contact with it and has given no trouble since.

Toronto, Ont., Canada. R. MCLAREN.

Unloading and Erecting Vertical Water-Tube Boilers

Some years ago I was sent to southern Louisiana to take charge of the erection of a branch factory including a power plant.

The original plans in the erection of the plant were to excavate a basement under the boiler and engine rooms. But when the ground was tested, there was only seven feet of clay on the surface over a bed of quicksand. So the plans were changed and boiler and engine-room floors were elevated one story and basement floors were laid on the surface. Foundations for the boilers and engines were started about a foot below the surface, which left about six feet of clay between the footings and the quicksand.

One of the first rigging jobs that turned up was to unload three 4,000-sq.ft. vertical boilers which arrived some time before the boiler footings were poured. The method of unloading the boilers and placing them in position is illustrated herewith.

As we were familiar with the methods of erecting this type of boiler, the railroad company was requested to bring the cars in with the smallest or lower drums of the boilers ahead. Two 10x10-in. timbers 40 ft. long were used for skids and were blocked up with cross-tie cribbing in line with the two drums. One side of car was shored up as shown to prevent it from tilting.

Owing to the supporting lugs on the lower drums of the boiler, it could not be rolled off the flat car. So the ends were jacked up one at a time and two iron plates put under each drum with a number of rollers between them and the car. The rollers were cut from 1-in. round iron and placed close together because the weight rested mostly on one spot. Several turns of cable were bolted around each end, leaving a long loop in which the boiler could turn. Into these loops snub lines were hooked, as shown. After both ends were resting on the rollers and the snub lines had been attached, jacks were placed under the rivet heads on both ends and the boiler moved sideways until the lugs could pass the floor of the car in turning, after which it was allowed to roll slowly down the incline, being held in check by the two snub lines, as shown in Fig. 2. A few weeks later, when the concrete footings were set, an erecting man from the boiler works arrived to assist us in the erection.

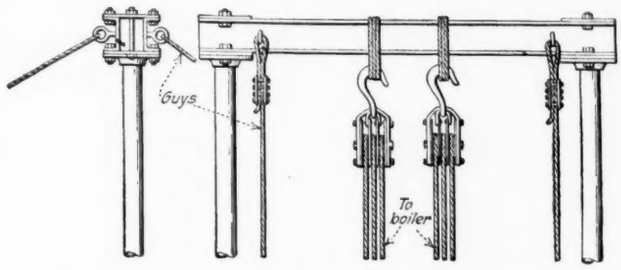
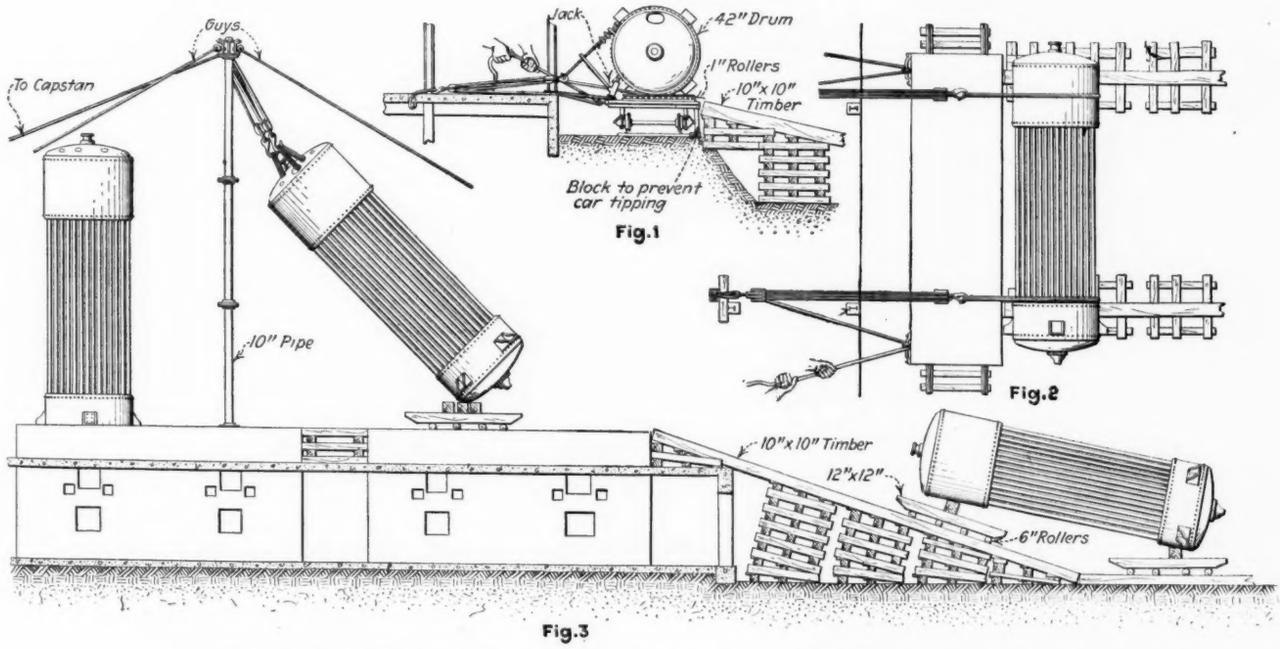


Fig. 4—Detail of frame used to place boilers in vertical position

With the long timbers previously used and some others, an inclined track was built up to the second floor of the boiler house and supported by cross-tie cribbing in a slanted position as shown in Fig. 3. Two skids were made from 12x12-in. timbers and placed under the drums with 6-in. wood rollers under them. The drums were then hauled up into the boiler house by 2-in. blocks with the pull rope running out to a capstan, to which a horse was hitched. When the boiler was at the top level, several king hole plates were removed, and cables were passed through them a number of times to provide a hitch for the blocks. To raise the boilers to a vertical position, we used a frame built as shown in Figs. 3 and 4. Two columns made from 10-in. pipe were used to support a structural steel girder to which the blocks were attached, the whole being stayed in six directions. Triple blocks were used with 2-in. rope, and the erector compounded them still more



Figs. 1 to 3—Tackle and rigging used in unloading and erecting vertical boilers

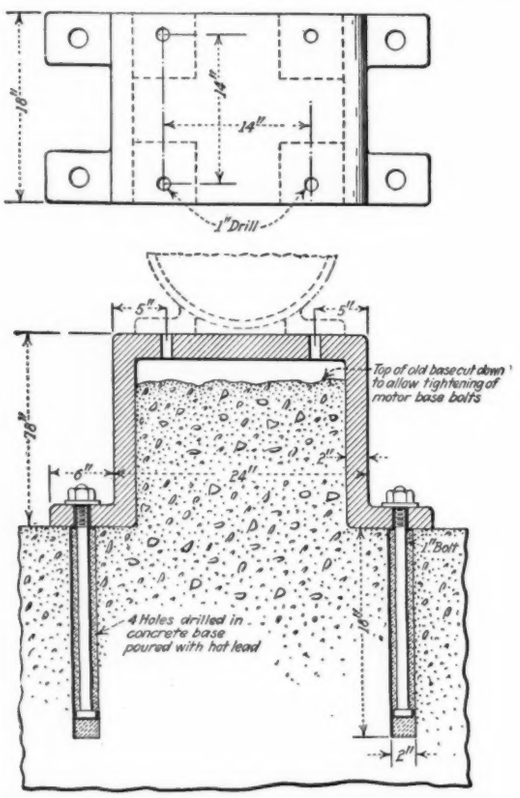
by additional snatch blocks above and below. A snub line was attached to prevent the boiler from straightening too suddenly and swinging in the opposite direction. Before the boiler was raised off the rollers, two additional timbers were laid across the back skids to provide a footing for the boiler as it was raised to a vertical position. One-half inch plates were laid on the foundation where the supporting lugs were to rest.

The leveling, plumbing and aligning of the boilers were done by driving steel wedges under the supporting lugs. To get a turning action, wedges were started under opposite lugs in opposite directions and two men driving them simultaneously. A. A. FETTE.

Cincinnati, Ohio.

Installing Bedplate Under Motor in Limited Time

At a near-by gas plant considerable difficulty was experienced with a high-speed blower unit. It was practically impossible to maintain correct alignment between the motor and blower as they were on separate bedplates.



Cast-iron bedplate was placed on old foundation and bolts grouted with lead

Investigation developed the fact that the concrete base under the motor was oil-soaked and crumbly, hence the holding-down bolts could not be kept tight. To tear out the defective base and pour a new one, and realign the unit would require at least two or three days, but as the plant was pushed for capacity, five hours was the maximum time that could be allowed for a shutdown. The method we finally employed of resetting the motor in the short time allowed is shown in the illustration.

The cast-iron bedplate was made extra-heavy as we were taking no chances, continuous service being our main consideration. All the planing and drilling were done beforehand. Bolts, washers, shims, etc., were provided so as to avoid any delay.

As soon as the motor was off the line and removed from its base, just enough concrete was cut away to allow the cast-iron bedplate to be set over the old oil-soaked base. The new bedplate was leveled, the motor bolted to it and lined with the blower. Then the foundation bolts were "grouted in" with lead.

The job was completed within the time allowed, and it proved so satisfactory that a similar base was put under the new blower motor which was then being installed. The additional expense was believed justifiable in view of the importance of the service.

Columbus, Ga. JOS. JACOBS.

Diagrams from Low-Pressure Cylinder with Condensing and Non-condensing Operation

It occurred to me that the accompanying diagrams obtained from the low-pressure cylinder of a 16x30x42-in. cross-compound engine might be of interest to other readers of *Power*.

The engine operates condensing, but the cutoff on the low-pressure side is controlled by hand, independent of the governor. The receiver of the engine is connected with the low-pressure process system, and the pressure is maintained at about 8 lb. by regulating the cut-off on the low-pressure cylinder.

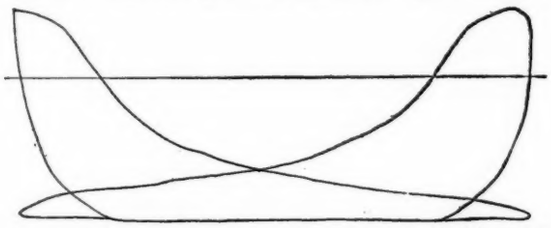


Fig. 1—Diagram from low-pressure cylinder while running condensing

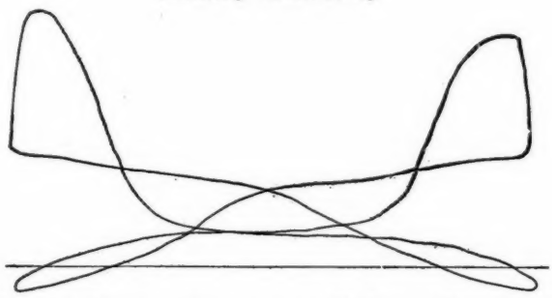


Fig. 2—Diagram from same cylinder as Fig. 1 with engine running non-condensing

Diagram Fig. 1 was taken from the low-pressure cylinder, while running condensing and carrying a light load. One morning, owing to some emergency repair work, the injection water to the condenser had to be shut off, which necessitated running the engine for a while non-condensing. Fig. 2 shows a diagram obtained during that time, the valve setting being left the same as when running condensing. I have shown this card to several engineers, but none of them had ever seen one like it before. WILLIAM HAMPSHIRE.

Webster, Mass.

Comments from Readers

What Causes the Black Spots?

On page 110 of the Jan. 20 issue, Mr. Gardner asks "What Causes the Black Spots?"

In reply to this question it is obvious from the data given that the armature winding is not sufficiently equalized. The addition of more equalizer rings, eight more if there is room for them, should help. As this is a doubly re-entrant winding, care should be taken that two of the four connections to any one equalizer ring go to circuit No. 1 and the other two to circuit No. 2.

LEONARD A. DOGGETT,
Assoc. Prof. Electrical Engineering,
State College, Pa. Pennsylvania State College.

Shall the Plant Put in An Oil Engine?

We have a 90-ton ice plant driven by compound condensing steam engines. Electric current is purchased for six months of the year when the plant is running full load. The average hourly consumption is 27 kw. and the best rate under the conditions outlined is 2½c. per kilowatt-hour.

The plan is to install a two-cylinder oil engine connected to a three-phase 60-cycle 220-volt generator. We should be interested in hearing from *Power's* readers as to the proper size generator to install—present plans call for a 37½-kva. machine. In addition some idea of the total cost of the engine and generator would be of interest, as would also the probable cost of generating power. The present crew would attend the oil-engine unit. We are especially interested in costs on actual operations.

L. G. BACK.
New York City.

Why Does the Temperature of the Furnace Walls Increase After Fires Are Extinguished?

Having had many years' experience with large boilers, both return-tubular and water-tube, I was much interested in the articles by M. S. Gerend in the June 17 and Aug. 12, 1924, issues and also the comments by Leroy Blake in the Sept. 16 issue, as to why the temperatures of the furnace walls increase after the fires are extinguished.

Our practice when shutting down a boiler for cleaning or making repairs, is to close the stack damper, and ashpit doors and allow the fire to burn down low before closing the stop valve. The boiler is then allowed to cool off without admitting any air through the furnace. We find that in this condition the boiler will cool off and show no pressure on the steam gage in about nine hours in winter and ten in summer.

The cooling is always followed by a steady drop in the steam pressure if the stop valve is tight but if the furnace walls do radiate heat, as stated in the articles referred to, there should be a pause at some point in the pressure drop and a tendency for the pressure to rise again, but I have never had any such experience. I have never made any tests on furnace walls with a thermometer, but I am inclined to think that the results of Mr. Gerend's experiments were due to some unusual condition. Probably someone can give us further enlightenment on this subject.

Norway, Mich. THOMAS PASCOE.

What Is Wrong with the Boiler Setting?

Referring to J. Billings' question in the Jan. 20 issue regarding trouble with settings of return-tubular boilers equipped with hand-fired stokers, some of the information is rather indefinite, particularly regarding the 4-in. draft. It would be presumed that this is ashpit pressure, and if so, it may be quite a large part of the trouble, as it is difficult to operate overfeed stokers with anywhere near such pressure, as it blows the fire in holes and gives a large excess of air in the flue gases.

It would help considerably if Mr. Billings could supply a sketch showing the approximate dimensions of the openings through the arch over the bridge wall and state whether the combustion chamber behind the bridge wall has been made thoroughly airtight. Air leakage in the side and rear walls of combustion chambers is very detrimental to boilers with high settings, though the high setting itself is an excellent idea and seems unlikely to be the cause of the trouble.

The foregoing comments are made without a full knowledge of conditions, but I believe if Mr. Billings will have flue-gas analyses made and temperatures taken at the boiler damper, also draft pressures taken from ashpit to stack, at the same time weighing the coal fired, he will be able to locate the cause of his trouble. Undoubtedly, he will find it due to one of the following causes: Poor firing, indicated by low CO_2, high flue-gas temperature, low draft loss through fire and high loss through boiler; leaky settings, indicated by low CO_2 and flue-gas temperature, normal draft resistance in fire and high in boiler; poor heat absorption, due to soot or scale, probably soot, indicated by normal CO_2, high flue-gas temperature, normal draft resistance in fire and high in boiler; or insufficient coal-burning capacity, indicated by normal CO_2, low flue-gas temperature, normal draft resistance in fire and an excessive drop in draft pressure at some point in the gas passages, possibly under the arch over the bridge wall, at the inlet to the tubes, or from damper slipped on rod. In the foregoing, normal CO_2 refers to 11 to 14 per cent and the normal draft losses those corresponding to the same rate of combustion on similar equipment, data on which are given in recent books on power-plant practice.

If the 4-in. draft is stack draft, it is almost certain that this is excessive, as under such pressure brick walls seem quite porous and every little crack will admit a considerable amount of air, so that the flue gases from the grate will be too much diluted and cooled to make steam with any efficiency. With ordinary damper

draft of 0.7 in. I have seen 20 sq.in. of opening around blowoff pipes pass half as much air as came through the grates of a 3,000-sq.ft. boiler hand-fired with bituminous coal, so it can be seen what such an excessive draft would do. In testing for CO_2 and draft losses, this excessive draft condition would show up as leaky settings, and the remedy would be to attempt to carry thinner and more uniform fires on the stokers and reduce the draft over the fire. This would probably call for more work on the part of the firemen in leveling fires, but should show material gains in capacity and reduced fuel consumption. H. D. FISHER.

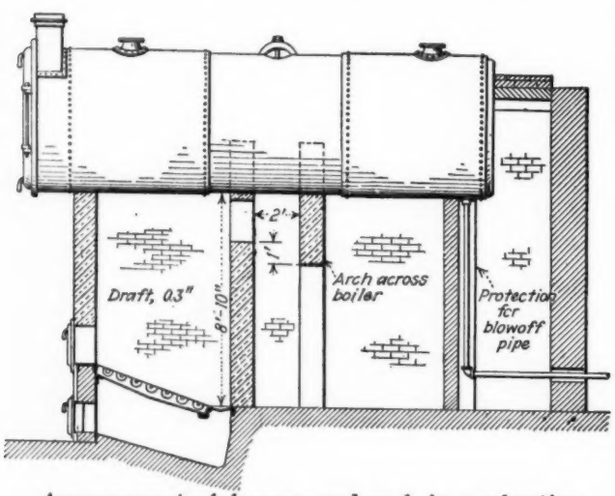
New Haven, Conn.

I do not believe Mr. Billings' trouble is due to the high setting. The probability is that there is a tremendous amount of excess air, and I suggest that he try operating with the damper three-quarters shut, and make sure that all the grate surface is covered. As soon as the ash is dumped, operate the kickers an extra amount to restore the fuel over the cut-out bars. Fire often and lightly, avoiding throwing the fuel to the rear, also, maintain about 12 in. of green coal in the coking zone.

I should say that 4 in. of draft is excessive. A half inch to an inch is ample, except when burning coke breeze. Make sure there is no leakage of air from the grates to the heating surface to reduce the flame temperature. Leakage between the rear combustion arch and the boiler shell is not uncommon. With the customary attention to flue cleaning and scale there should be little difficulty in securing 200 per cent of boiler rating at this plant. HARLAN W. BIRD,

Chicago, Ill. McClave-Brooks Co.

I would advise Mr. Billings to cut down the draft, as 4 in. is excessive. I would also suggest that he cut down the bridge-wall arch, which he says is 4 ft. each side of the bridge wall, and make it same width



Arrangement of furnace and arch in combustion chamber

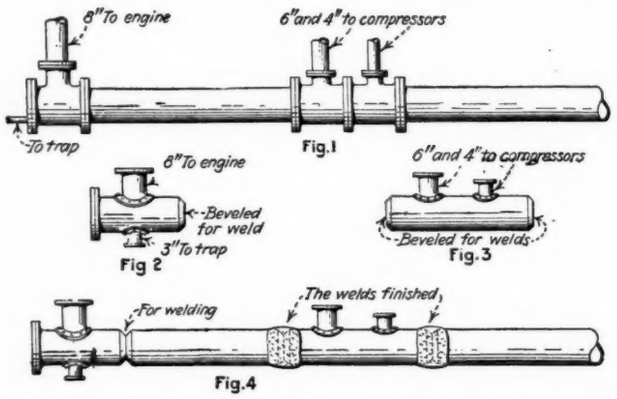
as the bridge wall. Then I would build another arch 2 ft. back of the bridge wall, as shown in the illustration.

The setting is very high, but I would not change it. It would appear that there is approximately 0.55 cu.ft. of combustion space per square foot of heating surface. This is not too much if the boilers are to be operated at 200 per cent of rating, which is common nowadays. I strongly advise him to make a CO_2 test while trying to carry the load, as I think that would show him the cause of his trouble, which is undoubtedly too much draft causing a high percentage of excess air.

Chicago, Ill. L. B. SHIELDS.

Welded Pipe Installations

The article by R. A. Cultra on "Welded Pipe Installation" in the Jan. 6 issue recalls a troublesome leak in the flange joints of a 14-in. steam header, that was finally eliminated by the welding process. Several kinds of packing were tried, but the joints could not be made to stay tight. Fig. 1 shows how the header was made



Figs. 1 to 4—Details of changes made in steam header

up with the flanged connections. It was decided to take out the tees and weld pieces in their place. Accordingly, two sections of pipe, beveled at the ends and with saddles riveted to them as shown in Figs. 2 and 3, were prepared.

At the first opportunity the steam was shut off the header and the tees taken out. The pipe was then cut off the proper length and beveled ready for welding. The welding was done by a competent man, and when the job was finished, steam was turned into header very slowly and the pressure built up. The job proved to be first-class and has given no trouble since.

Columbus, Ohio. A. C. LINDON.

High Bridge Station Correction

In the article describing the High Bridge Station of the Northern States Power Co., at St. Paul, which appeared in the Dec. 23, 1924, issue, there are two statements that should be modified.

The reason for omitting air preheaters was that it was not considered, at the time the station was built, that the development in this country warranted their installation. As a matter of fact, there is ample space for the installation of air preheaters in the boiler room and it is probable that in the near future an experimental installation will be made. Another point is that the superheat is 285 deg. and not 250 deg., giving a final steam temperature of about 705 to 710 deg.

Chicago, Ill. H. BOYD BRYDON, Mech. Engr.,
Byllesby Engineering & Management Co.

In welding heavy sections of metal where it is necessary to deposit several layers of metal, the surface of each layer should be cleaned before starting the next.

Questions and Answers

Conducted by

Franklin Van Winkle

Loss in Belt Transmission

In transmitting power by belts and pulleys, what is the average loss of power? W. C. T.

With usual sizes and speeds of belts and pulleys and where the belt tension is no more than necessary for transmission of the power appropriate for the size and speed of belt, the average loss of power from slippage, bending of the belt, air resistance and journal friction is about 3 per cent of the net power-transmitting capacity. The losses are substantially the same when such a belt is transmitting less than the appropriate maximum, but when overtaxed the loss of power from slippage alone frequently amounts to more than 5 per cent.

Horsepower Constant per Square Inch of Indicator Diagram

When indicator diagrams are taken with the same length of diagram and same scale of spring, how is the horsepower constant found per square inch of area of the diagrams measured with a planimeter? W. L. B.

The mean effective pressure for 1 sq.in. area of diagram would be 1 $\times$ *scale of spring* $\div$ *length of diagram in inches*, or *m.e.p.* $= \frac{s}{l}$, and this value substituted for P in the ordinary formula,

$$hp. = \frac{P \times L \times A \times N}{33{,}000}$$

gives *hp. per sq.in. of diagram* $= \frac{s \times L \times A \times N}{l \times 33{,}000}$; that is, *scale of spring* $\times$ *length of stroke in feet* $\times$ *area of piston in square inches* $\times$ *number of strokes per minute, divided by the product of length of diagram in inches multiplied by 33,000.*

Required Point of Cutoff Operating Non-Condensing and Condensing

With an initial pressure of 100 lb. gage, what would be the point of cutoff of a 22x42 engine running 85 r.p.m. when developing 350 hp. operating non-condensing with back pressure 2 lb. gage, and when operating condensing with 27 in. vacuum? R. L. N.

Development of the same power in each case will require the same m.e.p., namely:

$$(350 \times 33{,}000) \div (\textit{piston area in sq.in.} \times \textit{piston speed in ft. per min.})$$

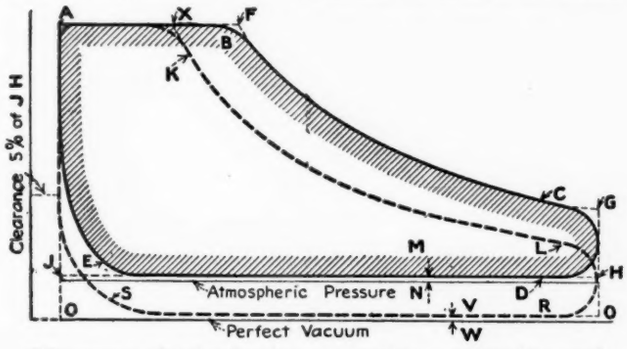
The piston area $= 22 \times 22 \times 0.7854 = 380.13$ sq.in., and the piston speed $= (42 \div 12) \times 2 \times 85 = 595$ ft. per min.; hence

$$m.e.p. = (350 \times 33{,}000) \div 380.13 \times 595 = 51 \textit{ lb.}$$

Assume that *ABCDE* in the illustration represents the indicator diagram made when the engine operates non-condensing, and *AKLRS*, drawn in broken lines, represents the diagram that would be obtained with the same load when operating condensing. When operating non-condensing, from drop of the initial pressure, during admission *A to B*, rounding of the diagram at cutoff as at *B*, release at *C* and compression as at *E*, the area of the actual diagram is about 94 per cent of the ideal diagram *AFGHJ* exhausting against the same back pressure *MN*, and the m.e.p. of the ideal diagram would be $51 \div 0.94 = 54.25$ lb. With back pressure 2 lb. gage, or 17 lb. per sq.in. absolute, the mean effective pressure with 0 back pressure would be $54.25 + 17 = 71.25$ lb.; for the initial pressure of 100 lb. gage or 115 lb. per sq.in. absolute, the m.e.p. with 0 back pressure would be $71.25 \div 115 = 0.619$ lb. per pound of initial absolute.

If *AKLRS* is the actual diagram when operating condensing with 27 in. vacuum and 30 in. barometer, with 54.25 lb. m.e.p. and back pressure $VW = 27$ in. above perfect vacuum, $00 = (30 - 27) \times 0.491 = 1.47$ lb. per sq.in. absolute; then with 0 back pressure the m.e.p. would be $54.25 + 1.47 = 55.72$ lb., and with initial pressure 115 lb. per sq.in. absolute, the m.e.p. per pound of initial when operating condensing would be $55.72 \div 115 = 0.485$ lb.

It may be assumed that the cylinder clearance volume is 5 per cent. When the average pressure $= P$, actual ratio of expansion $= R$, fraction of stroke at which



Diagrams obtained when operating condensing and noncondensing

cutoff occurs $= f$, and per cent of cylinder clearance $= c$, then

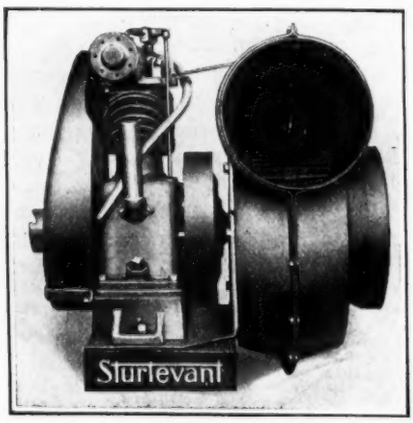
$$P = (1 + \log_e R)\ (f + c) + c$$

A table giving mean pressure per pound of initial with different clearances and points of cutoff computed from the foregoing formula is given, page 115 of F. R. Low's "Steam Engine Indicator." From inspection of this table it may be seen that the mean pressure, 0.619 per pound of initial absolute, which would be obtained with the same cutoff as when operating non-condensing, would correspond to cutoff F at about 0.24 of the stroke; and for the mean pressure of 0.485 lb. per pound of initial absolute, when operating condensing to develop the same power as when operating non-condensing, would correspond with cutoff at about 0.15 of the stroke.

New and Improved Equipment

Sturtevant Gaso-Fan

The B. F. Sturtevant Co., Boston, Mass., has recently added to its line of fans and blowers a small portable gasoline-engine-driven ventilating fan. as shown in the illustration. Although designed primarily for the ventilation of telephone manholes, the fan is equally adaptable for cooling small furnaces and ventilating tunnels or other services where a supply of air is required temporarily and where it is not convenient or possible to use motor-driven fans. The single-cylinder engine to which the fan is direct connected is four-stroke-cycle and is air cooled. Speed regulation, providing for constant speed, is obtained by means of an adjustable governor. The gasoline supply tank is in the base of the engine and the magneto is contained in the



Small gasoline-engine driven ventilating fan

flywheel, thus eliminating batteries and auxiliary tanks.

The unit is made in two sizes, a direct-connected unit (shown in the figure) having a capacity from 775 to 1,050 cu.ft. per min. and a belt-driven unit with a capacity ranging from 300 to 1,250 cu.ft.

Poole Reduction Gears

The Poole Engineering & Machine Co., Baltimore, Md., has recently brought out two types of reduction gears, known as types "H" and "K."

The type H gear, shown in Fig. 1, consists of a double-helical gear made from a steel forging and a herringbone pinion cut integral with high-speed shaft made of chrome-vanadium steel. Gear members are heat treated and ground and are tested for static balance before being assembled in the gear casing. The gears are totally inclosed in a cast-iron horizontally split casing. The bearings are removable and consist of cast-iron babbitt-lined shells, supported in bosses integral with top and bottom halves of casing.

For low-speed drives lubrication is obtained by a splash and gravity system in which the gear dips in the oil

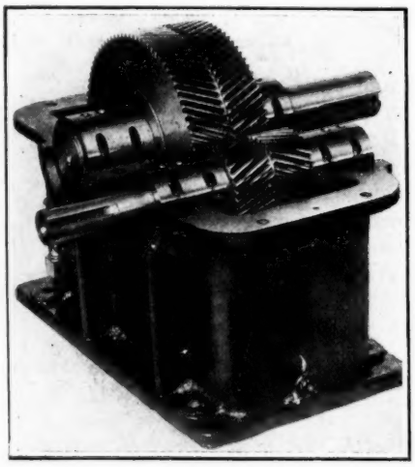


Fig. 1—Type H reduction gear with horizontally split casing

sufficiently to carry oil to a reservoir in the upper casing, from which it feeds to all bearings and directly between the gear teeth at the line of contact. For turbine and other high-speed drives, an oil pump and cooler are provided.

The type K reduction gear, illustrated in Fig. 2, consists of double-helical forged-steel pinion integral with the

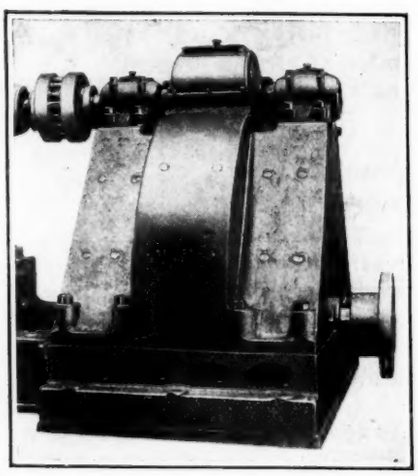


Fig. 2—Type K gear with shafts on vertical center line

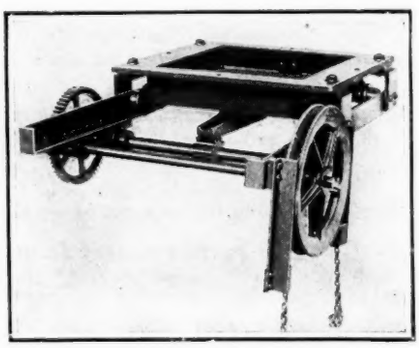
shaft and a cast-steel double-helical spur gear. Both gear and pinion have cut stub teeth. The gear and pinion shafts are mounted in babbitted bearings of the ring-oiling type and are lubricated by the splash system.

The high-speed shaft or driving pinion in this gear is located in the top of the casing with the driven shaft directly under it and just below or near the floor line. This feature makes the gear readily adaptable to certain types of machines used in industries where the lineshaft is close to the floor.

American Flat Ash Gates

In the accompanying illustration is shown a type of American flat ash gate brought out recently by the Conveyors Corporation of America, Chicago, Ill. The gate has been designed to stand rough usage, the materials entering into its construction being principally high-grade gray iron and steel, and the arrangement is such that none of the moving parts contacts with the descending column of ashes.

The steel members forming the runway for the gate rollers are bolted to



Hand-operated ash gate

the frame, with limit stops provided to prevent overtravel of the gate either at the extreme open or closed positions. The rollers, which are machined castings, are fastened to the gate by steel pins bolted into spot-faced and reamed pads cast on the sides of the gate.

Hand-operated gates are provided with a flat rack fastened to the under side of the gate casting, with the contact surfaces machined. A pinion, keyed on a cross-shaft, meshes with the rack, and the operation is effected by a crane chain operating in a rag wheel at the end of the cross-shaft. In the case of the smallest gate made —namely, 18x18 in.—power is transmitted directly through this cross-shaft and pinion to the rag wheel. In larger sizes of gate, illustrated herewith, an additional cross-shaft and pinion are provided to compound the gearing and minimize the effort required to operate the gate under all conditions of service. This compounding of the gearing also permits the use of a smaller rag wheel so that an outside dimension of 19¼ in. for all sizes will permit installation in comparatively small clearances. All roller and shaft

bearings are equipped with self-lubricating bronze bushings.

The gates are made in ten sizes ranging from 18x18 in. up to 24x30 in., with provision for chain operation up to 22 ft. from grade. In addition to the above hand-operated standard, the gate has been designed to take firebrick lining and for power operation.

Ranarex CO_2 Indicator and Recorder

Simplicity is a feature of a CO_2 recorder known as the Ranarex, now being introduced by the Permutit Co., 440 Fourth Ave., New York City.

An exterior view of the instrument is shown in Fig. 1, with a flow diagram,

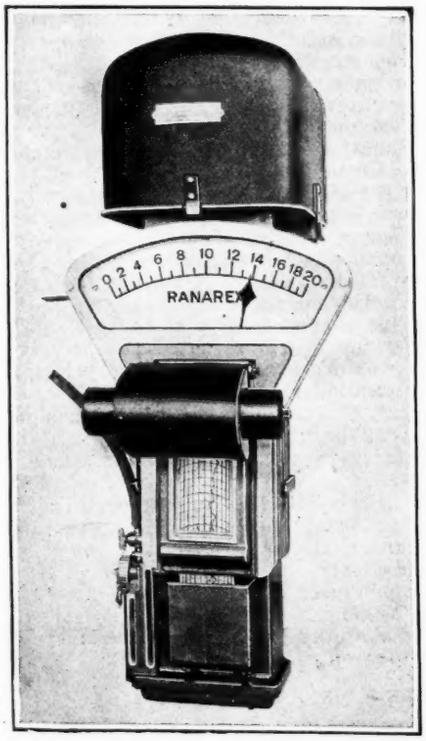


Fig. 1—Exterior view of instrument

Fig. 2. The apparatus contains two similar gastight chambers, one for flue gas and the other for air. A section of one chamber is shown at the right in Fig. 2.

Inside the chamber, the fan *A*, which is mounted on a shaft running on ball bearings and driven at a constant speed by an electric motor, causes a constant discharge of gas through the chamber. The whirling mass of gas exerts a force upon the impeller *B*, tending to rotate it, the magnitude of the force being proportional to the specific weight of the gas and therefore proportional to the CO_2 content. The details of the two chambers and fans are identical, the only difference being the driven impellers rotate in opposite directions and therefore produce opposing torques on the two shafts, *C*. These two shafts are coupled together by means of two levers which in turn prevent a complete rotation of the impulse wheels *B* and transmit a movement to a pointer, which designates the figures on a scale calibrated in terms of CO_2 content of the flue gas. The CO_2 indicated on the scale is recorded by a series of perforations on a strip of paper, the recording device also being driven by the motor.

Referring to the flow diagram, Fig. 2, it will be seen that the gas is drawn from the boiler and passes first through a filter, where the suspended particles

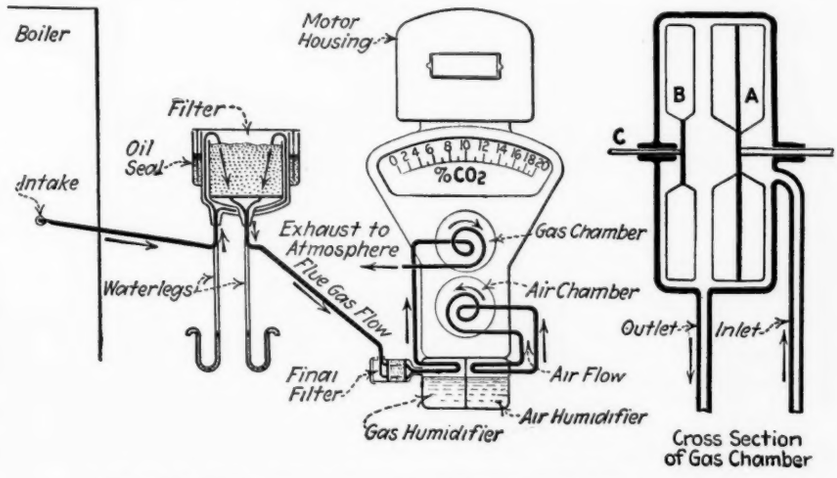


Fig. 2—Flow diagram of gas and air through instrument, also cross-section of gas chamber

are removed. The moisture that condenses from the gases is collected in the sealed water-legs, whence it overflows automatically. From the filter the gas passes through the final filter and thence through one compartment of the double humidifier, where it is brought to the same temperature and degree of humidity as the air that passes through the other humidifier compartment simultaneously. After leaving the humidifier, the gas passes through the gas chamber, whence it is exhausted to the atmosphere. The air, in the meantime, is circulated continuously through its humidifier compartment and the air chamber as indicated in the diagram, Fig. 2.

Since the amount of gas drawn through the chamber is large, the time lag is reduced to a minimum. The scale of the instrument is approximately 12 in. wide, and the figures are large, thus being easily readable at long distance.

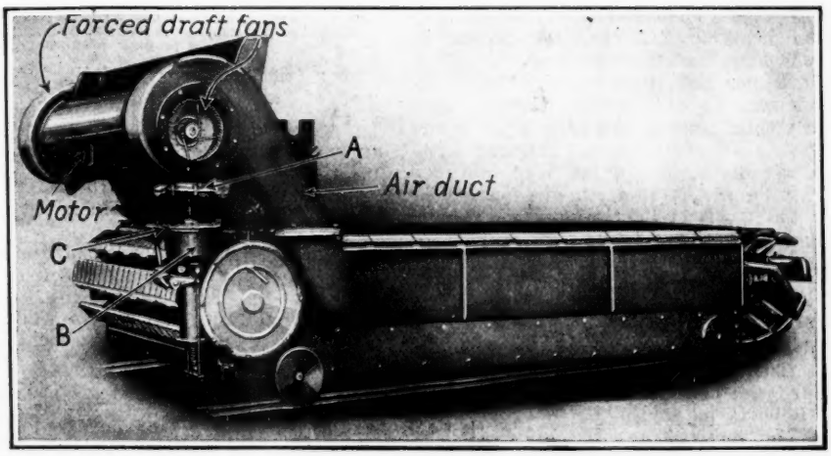
Self-Contained Traveling-Grate Stoker

The illustration shows a forced-draft chain-grate stoker that has been used extensively in Great Britain and Europe and is now being introduced in this country by the Combustion Engineering Corp., 43 Broad St., New York City.

By referring to the illustration, it will be seen that the stoker is self-contained and that the forced-draft fans are built in and form a regular part of the stoker. The two fans (one at each side) are mounted on a common shaft together with the armature of the motor. The air discharged by the fans is carried through ducts along the sides of the stokers and discharged below the grate. The supply of air is graduated from the front to the rear of the grate by a special damper mechanism operated from the front.

The grate is driven from the fan shaft through a silent chain and reduction gear. The silent chain forms the drive between the fan shaft and the worm gear *A* from which a vertical shaft extends downward to the driving gear, which is totally inclosed.

Provision is made for changing the speed of the grate independently of the motor speed by the change-speed gear *C*.



Traveling-grate stoker with self-contained motor drive and forced-draft fans

Hydraulic Turbines for Low-Head Plants

AT THE recent Annual Convention of the American Society of Civil Engineers, a symposium was presented before the power section of the society on high specific-speed hydraulic turbines in their bearing on the proportioning of the number of units in low-head hydro-electric plants. In this symposium there were six papers presented, abstracts of five of which are given herewith. A paper on "Comparison of Medium-Speed and High-Speed Hydraulic Turbines," by George A. Jessop, hydraulic engineer, S. Morgan Smith Co., will appear in a later issue.

High Specific-Speed Turbines

By George A. Orrok*

Among the many things of interest seen and heard at the World Power Conference (London, 1924), none perhaps was more striking than the variety of methods proposed and tried for the solution of the important problem of high-specific-speed turbines.

Of European large plants the Chancy-Pougny installation of five wheels (7,600 hp.), on the Rhone, below Geneva, Switzerland, is most interesting. The turbines are 18 ft. in diameter and operate under a 26.7-ft. head, with a characteristic speed of about 120. These units are just a trifle larger than those at Keokuk, Iowa. The wheels are a modified Francis type, retaining the outer rim, and are guaranteed to have an efficiency of over 90 per cent at the best gate opening.

NOTABLE EUROPEAN LOW-HEAD TURBINES

Location of Power Plant	Diameter, Feet	Discharge, Cu.Ft. per Sec.	Head, Feet	Revolutions per Minute	Horse-power	Specific Speed
Chancy-Pougny, Switzerland..	18	3,250	26.7	83.3	7,600	120
Lilla-Edet*, Sweden.....	19.66	5,200	21.3	62.5	10,000	136
Lilla-Edet†, Sweden.....	19	5,300	21.3	62.5	11,200	140
Siebenbrunn, Austria.....	6.25	.....	20.3	250	400	212
Gavle, Sweden.....	5	.....	13.75	250	400	219
Kachlet, Germany.....	15	.....	25.1	.....	7,450	115
Viereth, Germany.....	9.5	.....	17.4	.....	2,000	93
Wynau, Switzerland.....	10.83	1,700	17.0	107	2,700	165

* Lawaczeck wheel. † Kaplan wheel.

In comparison the Lawaczeck wheels for Lilla-Edet, Sweden, are 19 ft. 8 in. in diameter without the outer rim, and have a characteristic speed of 136; the head is 21.3 ft., the power is 10,000 hp. and the water used is 5,200 cu.ft. per sec., instead of 3,250 cu.ft. per sec., as at Chancy-Pougny.

A third unit in the Lilla-Edet[1] plant has a propeller-type runner with adjustable blades of the Kaplan type. This runner is 19 ft. in diameter and is rated at 11,200 hp. and has four blades which are adjustable while running. The design included a special draft-tube for each type of wheel. Actually, however, the second Lawaczeck runner was installed in a draft-tube designed for the Kaplan runner. Statistics of some of the high-speed European plants are given in the table.

Reports as to the performance and life of these large-sized and particularly high-speed runners will be watched for with avidity. The writer believes the high-speed runner has come to stay and that present difficulties with this type will be overcome, as with the older and better understood designs.

*Consulting engineer, New York City.
[1]Power Nov. 13, 1923, page 758.

Propeller-Type Turbines in Europe

By Charles C. Egbert*

It was not until about twelve years ago that the publication of the studies and experiments of Professor Viktor Kaplan, of Brunn, Austria, attracted attention to the possibilities of the propeller-type turbine, which has resulted in its development in both Europe and America. At first, engineers on both sides of the Atlantic were skeptical of Professor Kaplan's claims, but the adoption of the propeller turbine since has been an acknowledgment of his work.

The commercial application of the propeller turbine in Europe was undoubtedly retarded by the World War, nevertheless noteworthy progress has been made, which is indicated by a number of power plants in which various adaptations of the propeller-type wheel have been installed and the number of concerns building that type, of which there are at least twelve.

The accompanying table is given to show approximately the relative capacities of some large single-runner turbines, which have been installed in different countries.

One of the latest European installations is that of the Wynau Electricity Works on the Aare River in Switzerland, which includes two units of 2,700 hp. nominal capacity each. These machines operate at 107 r.p.m. under a variable head of 8.2 to 17 ft. Acceptance tests of these turbines indicate a maximum efficiency of 89 per cent, with a specific speed of 165 foot-pound units when operating under 17-ft. head. Under 8.2-ft. head at 85 per cent efficiency the specific speed is given as 195 foot-pound units. The generators are designed for a runway speed of 2.7 times the normal speed of 107 revolutions per minute.

*Consulting engineer, Niagara Falls, N. Y.

COMPARISON OF SOME LARGE SINGLE-RUNNER TURBINE UNITS

Power Plant	Head, Feet	Generator Output, Hp.	Speed, R.P.M.	Discharge, Cu.Ft.-Sec.	Type
Chancy-Pougny, Switzerland.....	26.7	7,600	83.3	3,250	Francis
Mississippi River Power Co., U. S. A.....	32	10,000	57.7	3,230	Francis
Cedar Rapids, Canada.....	30	10,800	54.3	3,730	Francis
Parahyba, Brazil.....	104	32,500	.....	3,120	Francis
Niagara Falls Power Co., U. S. A.....	213	70,000	107	3,250	Francis
Isle Maligne, Canada.....	110	45,000	112.5	4,100	Francis
Manitoba Power Co., Canada.....	56	28,000	138.5	5,100	Propeller
Lilla-Edet*, Sweden.....	21	10,000	62.5	4,900*	Propeller
LaGabelle, Canada.....	60	30,000	120	5,100	Propeller

* The maximum discharge of the Kaplan type turbine in the Lilla-Edet station, computed from the curves of guaranteed performance, is found to be about 6,100 cu.ft. sec. at 21.3 ft. head.

The Propeller-Type Turbine

By Lewis F. Moody*

It must seem surprising to anyone who has followed the development of engineering in the hydraulic-power field that a machine so highly developed as was the hydraulic turbine ten or fifteen years ago, should have suddenly entered on a period of radical changes and encounter transformations in many of its essentials. The fact remains, however, that although practice in turbine design had become almost standardized in the period just prior to the World War, the development of this art has taken on new life and has already been revolutionized in many aspects. The most striking changes have been those in runner and draft-tube design, resulting in a remarkable increase in the specific speeds. This change from a so-called Francis turbine to a turbine of the propeller type involves the following principal alterations:

A. The elimination of the runner band or shroud ring, allowing the blades to rotate within a stationary wall.

B. The introduction of a large transition space between guide vanes and runner, in which the water follows a free path and turns from a radial to a partly or completely axial direction.

C. The reduction of blade surface so that the blades either overlap each other only slightly or fail to overlap at all and leave clear openings between them.

D. A reduction in the number of blades.

E. The use of draft-tubes symmetrical about the turbine axis and capable of efficiently converting into useful head the velocity head of both meridian and tangential components of the runner discharge velocity, thus permitting both components to be made relatively large.

The effect of each of these changes is to allow the runner to be operated at a high speed under a given head, by permitting higher relative velocities

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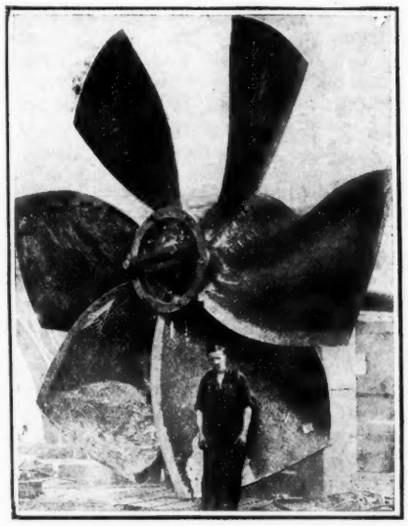
to be used and a more inclined direction of the absolute velocity of runner discharge.

The reason for eliminating the band or shroud is simple. With the runner speeds and diameters used, the relative velocity of the water in contact with a moving band would be considerably greater than its absolute velocity along the surface of the stationary wall, so that there is less surface resistance on the inner surface of the band when it is stationary than when it rotates; and by replacing the rotating band by a stationary wall, the frictional resistance of its outer surface is eliminated.

The effect of the transition space is to reduce the relative velocity between the water and the blades at all sections except at the blade tips. If this space is too much enlarged, however, or if the entrance edges of the blades are carried too near the axis, the relative velocity near the hub begins to increase again, the water at that point then tending to rotate faster than the runner, and, in addition, the surface friction due to the long path along the stationary head cover partially discounts the decrease in blade friction. This consideration is one of those which have led to the writer's diagonal type runner, intermediate between a radial and a purely axial-flow runner. In a similar way an undue reduction in blade surface while decreasing the surface resistance, if carried too far results in imperfect guidance of the



Runner for 30,000-hp. propeller-type turbine to operate under 60-ft. head

flow and permits other losses that more than offset the gain. It has been found both from theory and experience that unduly small blade area greatly impairs the stability of operation, giving rise to surging, unstable flow and loss of efficiency and materially reduces the field of application of turbines of the propeller type in which it is found.

It may be stated that although as a result of experience with this new form of turbine, certain minor defects have developed which have required for their correction some modifications in design, the many major difficulties that had been predicted, such as serious corrosion, vibration, imperfect regulation, failure to develop the power corresponding to the head, or refusal to run under low head, have not occurred.

High-Speed Suction Turbines

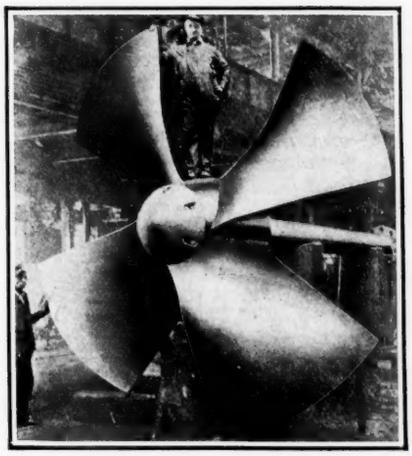
By Forrest Nagler*

The high-speed axial-flow type of hydraulic turbine runner, called variously in the United States the "suction runner" or "propeller runner," is generally representative of a type wherein the flow within the runner itself is in a direction mainly parallel to or "cylindrical" about the axis of rotation.

One of the principal characteristics of this type of runner is its lower efficiency at partial loads, as contrasted with those of lower speed, such as the Francis type. For example, the efficiency at half load of a high-speed runner having a characteristic speed of 175 is about 66 per cent. The corresponding efficiency at half load of a Francis runner having a specific speed of 100 is approximately 75 per cent. Francis runners of low capacity, for specific speeds of 40 or 50, have reached as high as 90 per cent efficiency at half load, but these runners have not the characteristics that will permit of their application to low heads and, consequently, the comparison is a technical and not a practical one. In actual service the efficiency at part gate is little or no handicap except in plants where there may be a small number of units. It is not a considerable factor when there are more than two units in the station, because under ordinary working conditions, the operation may be maintained at or near the point of best efficiency by intermittently shifting the load or by drawing on the pondage. This possibility, combined with the fact that the over-all operating efficiency of the high-speed unit under low-head conditions (including the generator) is usually superior to that of a Francis unit, makes this type economical regardless of the saving in initial cost.

One of the features encountered earliest in designing and experimenting with this type of runner is the possibility of varying its capacity widely without materially affecting its efficiency. It is simply a question of flattening the blade angles. European practice has apparently taken advantage of this fact and carried the application of this principle even so far as to make the blades movable under control of the governor, either simultaneously with or separately from the similar control of the guide vane. Hydraulically, there is no question as to the results; mechanically, such a construction may come well within the standards of European practice, but the writer does not believe that it will ever become popular under American standards of simplicity, of ruggedness and of high costs of labor. The need for such a construction does not enter into consideration when there are many units in the station. Governors are becoming less and less a factor, and the writer believes they will ultimately cease to enter into hydraulic turbine design to any appreciable extent, their ultimate elimination being due to the fact that hydro-electric systems will be largely interconnected with steam power where regulation is inherently less harmful to structures and to economy.

Governor regulation has not been as perfect as that obtained with corresponding types of Francis units, but



Runner for 2,200-hp. suction-type turbine to operate under 13-ft. head

this is principally attributable to the fact that with the higher speeds in question, the factor WR^2, of the generaator has beene relatively lower. The regulation experienced has not differed from that obtained with Francis units by an amount unexplainable by this reduction of regulating constant.

The high-speed suction-type runner, because of its higher and sometimes critical velocities, is not conducive to as quiet a running machine as the Francis runner, perhaps in exactly the same way that the flow conditions in a Francis runner are not conducive to as smooth operation as is possible with an overshot wheel. Nothing, however, of a nature that would make it uncommercial has been experienced with this type when it is used under conditions to which it is inherently adapted; that is, relatively low head and large capacity.

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Proportion of Units in Low-Head Plants

By John P. Hogan*

In proportioning units for a plant, the controlling factors in determining the number of units, assuming load regulation to be provided from other sources are: Maximum head and variation in head; character of the stream flow; speed of units; efficiency and velocity of approach and discharge of water.

For ordinary service on a fluctuating flow and varying load the Francis wheel, with its relatively flat efficiency curve at varying flows, is the ideal. The limit of size in Francis wheels

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for low heads is soon reached, owing to decrease of speed in proportion to the increase in size.

For a 30-ft. head the normal Francis runner operating at full efficiency should have a specific speed of about 90. For a 30-ft. head and specific speed of 90 the characteristics of normal Francis wheels of various sizes would be approximately as shown in the table.

CHARACTERISTICS OF A NORMAL FRANCIS TYPE TURBINE

Quantity of water, Cu.Ft. per Sec.	Revolutions per Minute	Electrical Horsepower
500	170	1,330
1,000	125	2,660
2,000	85	5,300
4,000	55	10,800

For the largest size shown, the size and cost of the wheel and generator become almost prohibitive. It will be readily seen, therefore, that speed fixes a definite limit to the economic size of Francis wheels for low-head developments. Various experiments have been made with special designs and modifications of Francis wheels to exceed the normal specific speeds, but in the writer's opinion these do not promise a solution of the problem.

Designers and manufacturers, both in the United States and abroad, have put at the disposal of the constructor and operator special types of wheels to meet this situation, which heretofore have been called propeller wheels. These wheels have somewhat different designs and different spheres of usefulness, but they have the common object and result of increasing the specific speed at a slight loss in maximum efficiency.

The result is increase in speed of wheel and generator for a given quantity of water and consequent decrease in cost of wheel and generator or a decrease in the number of units, all resulting in power-house savings. A normal propeller wheel operating on a 30-ft. head will probably take 4,000 cu.ft. per sec. of water at 85 r.p.m. and would be therefore roughly equivalent to the 2,000 cu.ft. per sec. Francis type of wheel operating at the same speed, although the propeller wheel will develop nearly twice the power.

This is of no importance in continuous plants of large flow where the number of units is so great that sufficient flexibility can be obtained by combinations of units. With stream-flow plants, on the other hand, it is probable that at low flows the combinations of propeller wheels of large flow might give low efficiency and capacity at the most critical periods and that economy will dictate the use of two types of wheels of which the majority will be propellers and the minority either Francis or special wheels having characteristics similar to those of the Kaplan wheel. This has already been done abroad for a low-head plant, as at the Lilla-Edet installation, Sweden.

In peak capacity plants it will be easier to arrive at a compromise in the number of units which at the same time will permit a large wheel and efficiency at relatively small daily flows, since it will be possible to operate for a relatively short period of time on a concentrated flow.

Electrical Engineers Hold Thirteenth Midwinter Convention

THE thirteenth annual midwinter convention of the American Institute of Electrical Engineers was held in the Engineering Societies Building, New York City, Feb. 9 to 12, with a total registration of 1,450. On Wednesday evening the Edison Medal was presented to John W. Howell for his contribution toward the development of the incandescent lamp. John W. Lieb made the presentation address. Thursday evening in the grand ballroom of the Hotel Astor the dinner dance was held. This being on the evening of Lincoln's Birthday, an unusually large number attended.

President Harvey Osgood, in opening the convention on Monday afternoon, said that last year the convention was held in Philadelphia, the first time it has been outside of New York. This year it was decided to hold it in New York again. Although this did not necessarily mean that all future midwinter conventions would be held here, it was somewhat of a settled policy that these conventions should be held in New York or somewhere near.

John W. Howell

President Osgood referred to the district conventions, which are being developed, and said these are progressing very favorably and it was hoped they would become comparable with the national conventions. It is anticipated that these conventions will take over some of the work of the national meetings since there is not room enough nor time enough at the national conventions to present all the advances made in the art of electrical engineering. Therefore, by building up the district conventions to the standards of the national, it would make possible devoting more time to the many phases of electrical development.

The speaker also made mention of the research fund of the Engineering Foundation, and inferred there were favorable prospects of its being materially increased. One engineer, Ambrose Swasey, has already made a very generous beginning by his gift of one-half million dollars. It was Mr. Osgood's opinion that this fund should be increased to at least $20,000,000, which at 5 per cent would make possible $1,000,000 per year for research purposes.

Six Technical Sessions

Six technical sessions were held: Two under the auspices of the Committee on Electrical Machinery, H. M. Hobart, chairman; one each under the auspices of the Committee on Power Transmission and Distribution, P. H. Thomas, chairman; Electrophysics Committee, J. H. Morecroft, chairman; Committee on Instruments and Measurements, A E. Knowlton, chairman; and Committee on Communication, O. B. Blackwell, chairman.

One paper of particular interest to readers of *Power* is that on "The Effects of Full-Voltage Starting on Induction Motors," by J. L. Rylander, which gives the results of experimental tests on starting squirrel-cage induction motors on full rated voltage and a study of such starting in service and bracing of the end windings. The following is an abstract from this paper:

On certain applications it is desirable to have motors start from rest or at some reduced speed without the aid of an attendant when the power on the line fails and then comes on again. This is accomplished by omitting the customary auto-starter and connecting the motor directly to the line, thereby impressing on the winding full-line voltage instead of reduced voltages of 50, 65 or 80 per cent.

Effects of Full-Voltage Starting

To determine the effects of full-voltage starting on the windings of squirrel-cage induction motors two machines were chosen for making thorough tests. One was a 50-hp. three-phase six-pole 440-volt 60-cycle 1,160-r.p.m. squirrel-cage motor, the other a 500-hp. three-phase four-pole 2,200-volt 25-cycle 724-r.p.m. motor of the same type. The windings were of the open-slot type. There was no special coil bracing on these motors. The deflection of the coils was measured with the aid of a special measuring device called the vibrograph. There was either quivering, vibration or displacement of the windings during starting these two motors. The severity of the motion or displacement of the windings increased as a function of the square of the voltage applied to the particular winding; that is, a 440-volt or 2,200-volt motor is no worse than a 220-volt motor with regard to the effect of voltage alone, but 440 volts will produce four times as much coil displacement as 220 volts on a particular winding, regardless of the voltage rating.

When the windings were displaced, the displacement was toward the frame in all cases except when starting the motor with an auto-transformer starter. The windings move and vibrate in both radial and tangential directions.

The amount of coil movement and its

duration, as shown in the vibrograph curves, correspond with the starting current on the oscillograph curves taken simultaneously with them.

Starting motors with full voltage produces a severe strain for a short period, whereas the use of an auto-transformer starter produces a less severe strain for a longer period and also a momentary strain that may be more severe than when starting with full voltage. The auto-starter may produce two severe shocks on the winding in opposite directions. This is accounted for by the voltage that is produced in the winding being out of phase with the line voltage at the instant of changing from the lower-voltage tap to the full voltage tap of the auto-starter.

The attraction and repulsion of the conductors on each other tend to move the conductors and is opposed by the mechanical fastenings that support the conductors. Many of the conductors are secured by resting against other conductors, which are secured by various means. As all armature conductors pass through the slots, the slots become an effective means of securing a large part of each conductor. Beyond the slots a number of the conductors are bound together in a unit as a coil, and this prevents the conductors from vibrating against each other. Each coil end tends to move under the effect of the force exerted on it by all other coils in the machine, but is resisted by the rigidity of the coil as each coil is held by being placed in two different slots and usually at one or more other places on ends of windings by means of rope, bolts, clamps or steel bands to other more or less fixed supports.

The vibration and movement of the windings deteriorate the insulation, and if sufficiently severe, will cause an insulation failure. It may also break the coil leads.

The kind and amount of insulation and the method of bracing are the limiting factors that determine how much vibration or coil movement can be permitted. The repetition of these vibrations sometimes has a cumulative effect by loosening the rope that is generally used to secure the coils to a supporting ring.

As the amount of vibration or coil movement is directly proportional to the square of the ratio of the starting current to the full-load current, the starting of squirrel-cage induction motors is much more severe on the windings than it is with wound-rotor induction motors where the current is limited by the resistance in series with the secondary. As the amount of vibration is also directly proportional to the third or fourth power of the length of coil between supports, very thorough bracing is required where the coil extensions are comparatively large. Nevertheless, there seems to be no doubt that all induction-motor windings can be satisfactorily braced to stand the mechanical effect of full voltage starting.

New A.-C. General Purpose Motor

H. Weichsel presented a paper entitled "A New Alternating-Current General Purpose Motor." This motor combines the starting characters of the induction motor with the running characteristics of the synchronous motor. Its outstanding features are:

1. Operates over the whole normal working range with leading or unity power factor.
2. When operated in parallel with induction motors, the leading power factor of this new motor counteracts the lagging power factor of the induction motors.
3. The starting characteristics are as good as those of an induction motor with wound secondary.
4. It is able to operate at heavy temporary overloads.
5. From no load to about 150 to 200 per cent load, the machine operates as a synchronous motor. When the load increases beyond these values, it operates as an induction motor, and if the load is again decreased to values in the neighborhood of 150 to 200 per cent of normal, it automatically returns to synchronous operation.

Discussion on New Type Motor

In discussing the paper it was pointed out that this is a synchronous motor with an induction-motor air gap. Although it was admitted that the motor's power-factor characteristics made it a very desirable machine to have on the system, there was some doubt expressed as to the economical application of the motor unless a favorable rate could be obtained from the power companies for good power factor to compensate for the increased cost of the new type motor over that of an induction type. To carry a lot of wattless current in a power system is a bad thing, but whether the time has arrived to do away with it is another question.

Among the objections raised against the new motor were its higher initial and operating costs when compared with an induction motor and the double winding on the rotor.

Attention was called to the characteristics of the motor to carry heavy overload as being desirable for certain applications where the motor may be subjected to heavy overloads for short periods.

The opinion was expressed that there was a tendency in industries to install a mixed system of motors, using both direct-current and alternating-current machines. In such cases the solution of the power-factor problem was to be found in supplying the direct current from direct-current generators driven by synchronous motors, the synchronous motor also compensating for the poor power factor of the induction motors on the alternating-current load.

Farley C. Ralston in a paper, "Predicting Central-Station Demand and Output," investigated the nature of the seasonal variations in the daily load curve of the Philadelphia Electric Co., as these variations affect the output and peak demand.

The variation of the kilowatt-hour output is first analyzed and it is found that in a year fairly free from abnormal-business conditions, a plot of the "normal midweek day" outputs on semi-logarithmic paper can well be rationalized to a curve whose components are an inclined straight line and a single-frequency sine curve. This curve is represented analytically by an equation.

Factors are included for determining the output on holidays, Sundays, Mondays and Saturdays, as compared with adjacent "normal midweek days."

For short-term peak demand predictions, the method employed is to separate into three components that portion of the daily load curve beginning at 2:30 p.m. and ending one and one-half hours after sunset. These three components are a constant base load, an afternoon block and an evening block, which are also introduced into a formula.

A paper on "Storage Battery Electrolytes," by C. W. Vinal and G. N. Schramm, will appear in abstract in a later issue.

Direct-Connected Turbines Compared with Geared for Ship Propulsion

The advantage of geared turbines over the direct-connected for ship propulsion is well illustrated in the reconditioning of the steamship "Drottningholm." This was originally equipped with Parsons marine turbines in 1905, and changed over to geared turbines for the three shifts in 1922, as described in the Dec. 19, 1924, issue of *Engineering* (London).

In the case of a direct-driven ship sacrifices must be made in propeller efficiency as well as in turbine efficiency, in order to secure a rate of shaft revolution which will not be excessively high for the propeller or excessively low for the turbine. This compromise works to the greater disadvantage of the slower ship, so that for cargo boats the turbine direct drive offers few if any advantages.

In the original installation a high-pressure unit drove the center shaft, exhausting into a low-pressure turbine on each side, which drove a wing shaft. The original propeller speed of 300 r.p.m. was reduced to 200 r.p.m. The ship was changed over from coal to oil at the same time, and means were provided whereby the vacuum was increased about ¾ in.

Test trials indicated that the steam consumption was about 50 per cent less with the new turbines, while they, with the reduction gears, weigh approximately 50 tons less than the direct-drive turbines. The high-pressure turbine developed 3,998 hp. and the low-pressure turbines together 6,040 shaft hp. While the original machinery made it possible to complete a voyage on 2,400 tons of coal at 14.2 knots, the improved equipment gave 16.3 knots on 950 tons of oil. Assuming 5 tons of oil equal to 8 tons of coal, and reducing the coal-consumption figures to the same speed, the net gain shown is about 50 per cent.

The high-pressure-ahead turbine in this instance has six impulse wheels of about 5-ft. diameter with a designed speed of 2,400 r.p.m. or eight times that of the original direct-coupled high-pressure machine. Steam is exhausted at 30-lb. gage into the wing low-pressure turbines, which also operate at 2,400 r.p.m. and contain six single-row stages each.

Muscle Shoals Conference Bill Reported

In the Conference Report, just issued by the Muscle Shoals Conference Committee, which is to accompany H. R. 518 bill, compromise was made by both sides to enable action to be taken by Congress at this session. The report provides for national defense and the manufacture of nitrogen. The President is empowered to lease the properties of Muscle Shoals, including Dam No. 3, for a period of fifty years to an American citizen or citizens.

Some of the outstanding points, of the leasing section of the report are: In case of necessity the United States can, on five day's notice, take over all or any part of the plant for the manufacture of explosives, etc.; provision is made that 10,000 tons of fertilizer must be produced the third year of the lease period and must be increased up to an annual production of 40,000 tons during a ten-year period; farmers and other users are to be supplied with fertilizers at prices not to exceed 8 per cent above a fair annual cost of production; should the United States terminate the lease at the end, it can resume possession upon payment of a fair value for the improvements, etc.; the annual rental shall not be less than 4 per cent, for the period of the lease, on the total sum expended on building Dam. No. 2 and Dam No. 3; the lease shall also provide the terms and conditions under which the lessee may sell and dispose of surplus electric power generated; failure of the lessee to comply with the terms of the contract shall render the same terminable upon six months' notice at the option of the United States, whereupon the United States shall proceed immediately to maintain and operate the leased property.

Government Operation an Alternative

In the event that the President is unable to make a lease before the first day of December, 1925, then the United States is to maintain and operate Muscle Shoals according to provisions included in the bill. The name, powers, capital stock and bonds, distribution of earnings are all provided for in Sec. 7.

Miscellaneous Provisions

Sec. 8 authorizes the President to complete the construction of Dam. No. 3 and the sum of $3,472,497.25, the proceeds from the sale of the Gorgas steam power plant, is allotted for this purpose.

Provision is made in Sec. 9 that all surplus power not required for the manufacture of nitrogen or fertilizer or other useful products, which will reduce the cost of fertilizer, can be sold for distribution with the proviso that such power may be withdrawn on reasonable notice at any time during the lease period should it be needed for the manufacture of fertilizer. Any lessee of power must conform to all rates, charges of payment, etc., as may be prescribed by the state in which the service is rendered or the rate charged. Provision is made for supervision when the state does not have a commission to regulate or control rates.

Section 10 provides that not less than $50,000 be expended annually for ten years or thereafter any such amount as the President may designate, under any lease made, in electrochemical research at Muscle Shoals on production of high-grade fertilizer materials, war gases, light metals and other electrochemicals or electric-furnace products suitable for national defense.

This research is not to be confined to laboratory work, but includes investigation made on a commercial scale. The President is empowered to employ officers and experts and is allowed $100,000 to carry out this provision.

To the end that the fertilizer produced be sold at 8 per cent above cost of production, the creation of a board is authorized, which is to include members of farm organizations and appointees by the President.

D. C. Engineers' License Bill To Be Amended

The District of Columbia Committee of the House of Representatives has agreed on amendments to the act regulating the operation of engines in Washington. In its report to the House, in which the passage of its bill is urged, the committee among other things says:

"The present bill in operation in the District of Columbia for the licensing of engineers was passed in 1887. At that time there were very few engines, if any, operated in the District of Columbia except those operated by steam. Since that time, due to development, internal-combustion engines and refrigerating machines have come into use and it is deemed wise to have some law regulating the licensing of engineers who operate these very dangerous machines.

"The amendments are desirable in that they provide for including engineers operating other than steam plants, such as gas engines, gasoline engines and electrical and refrigerating machinery, thus meeting modern requirements."

The amendments recommended by the committee require the owner of the plant to know that his engineer is licensed and provide punishment for the unlicensed operator and the man who hires him. In the penal clause the jail sentence is eliminated and the fine reduced from $50 to $40, so that the delay incident to a jury trial is avoided.

Licensed engineers also are required for engines equipped with automatic safeguards. "Disasters in the District of Columbia caused by too much dependence being placed on automatic appurtenances" led to this action. An exception is made when the water returns to the boiler by gravity. The present law allows licensed engineers from any state to practice in the District of Columbia, notwithstanding the fact that a similar privilege might not be extended the licensed engineers of the District of Columbia. Under the proposed changes this right would be extended only to those states granting reciprocity to District of Columbia engineers.

Ten-Million Dollar Plant for Scranton

Four hundred and sixty acres of land above West Pittston have been acquired by the Scranton Electric Co., as the site for a future plant to serve Scranton and other places in the Lackawanna and Wyoming Valleys. The cost of the new plant is estimated at $10,000,000, and tentative plans call for the initial installation of two single-unit turbines rated at 40,000 kw. each. The plant will be steam-operated and similar to the Philo plant now being built near Zanesville, Ohio, for the Ohio Power Co., which like the Scranton company, is a subsidiary of the American Gas & Electric Co., according to recent press reports.

Interesting Film "Power" Ready for Release

A motion picture "Power" has just been completed by Stone & Webster and is now ready for release. It is an interesting and non-technical story of the progress man has made in the development of power from steam, from the first crude piston engine to the steam turbines of the present day. Animated drawings have been used throughout the film to show such things as the operation of a steam turbine; just how alternating current is generated, etc.; relative importance of water power compared with the coal deposits of the United States; and an interesting illustration of the tremendous quantity of coal used in the United States.

The latter part of the film is devoted to actual construction scenes of a large central power station and ends with an animated chart which indicates that we are just beginning a period of remarkable power development.

Government Wants Young Engineers

The United States Civil Service announces examinations for engineers as follows: Junior patent examiners for Patent Office at entrance salaries of $1,860, examinations to be held April 22 and 23; assistant mechanical engineer, (cryogenic) for the Bureau of Mines for duty at Lincoln, Neb., entrance salary $2,100, non-assembled examination with date of application closing on March 10.

Kansas City Would Abolish Smoke Nuisance

A determined effort to control the smoke nuisance in Kansas City has recently been started. It is to be largely of a co-operative nature. A city ordinance, in existence for several years, can be used effectively, it is believed. But the present move of city authorities is designed to secure the aid of the industries, railroads and individual residents.

The city building inspector, in charge of smoke inspection, estimates that the annual loss of the city in laundry, housefurnishing and other bills is $6 per capita.

Careful habits of firing, regulation of drafts and, in the cases of a few big industries, the installing of smoke-consuming devices, are held to be the only requirements for control of the nuisance. Instruction in firing, the handling of boilers and residence and apartment heating plants, are to be given by city inspectors wherever possible.

Research Graduate Assistantship at Urbana

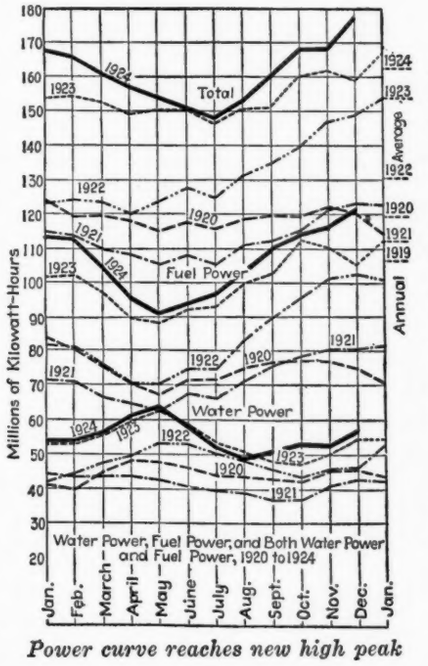
To assist in engineering research and to extend the field of its graduate work in engineering, the University of Illinois maintains fourteen research graduate assistantships in the Engineering Experiment Station, Urbana-Campaign, Ill. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

An appointment to the position of research graduate assistant is made and must be accepted for two consecutive collegiate years of ten months each, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Half of the time of a research graduate assistant is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study.

Nominations of these positions, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the Director of the Station each year not later than the first day of April.

Production of Electricity Gains During 1924

The total production of electricity by public-utility power plants in 1924 was 58,996,000 kw.-hr., 6 per cent larger than the output for 1923. The output by the use of water power was 33.9 per cent of the total, a reduction of about 1 per cent from the 1923 figure. The amount of coal used to generate electricity in public-utility power plants decreased nearly 4 per cent compared with that for 1923, while the consumption of oil and gas increased about 14 and 54 per cent, respectively. The percentage increases for oil and gas appear to be relatively large, but the total oil and gas consumed in generating electricity is equivalent to only 15 per cent of the total coal consumed. The



Power curve reaches new high peak

decrease in the amount of coal consumed considerably more than balanced the increase in the consumption of oil and gas, according to the Geological Survey.

The continued increase in efficiency in the use of fuel by public-utility power plants is shown by the reduction of one-fifth of a pound of coal used to generate a kilowatt-hour of electricity in 1924 as compared with 1923. It would have required about 3.9 million more tons of coal to generate the output of electricity in 1924 by the use of fuels at the 1923 rate per kilowatt-hour.

The average daily production of electricity in December was 177,600,000 kw.-hr., about 5½ per cent larger than the average daily output for November, 1924, and 11.6 greater than the average daily output for December, 1923. The output of electricity by public-utility power plants in December, 1924, was by a considerable margin the largest ever produced in any previous month.

The average daily production of electricity by public-utility power plants and the proportion produced by water power for each month of this year were as follows: January, 167,400,000 kw.-hr.. 32.3 per cent: February, 166,700,000 kw.-hr., 32.3 per cent; March, 160,800,000 kw.-hr., 34.4 per cent; April, 158,000,000 kw.-hr., 39.2 per cent; May, 154,600,000 kw.-hr., 40.7 per cent; June, 151,800,000 kw.-hr., 37.5 per cent; July, 148,800,000 kw.-hr., 34.8 per cent; August, 152,700,000 kw.-hr., 32.0 per cent; September, 160,100,000 kw.-hr., 31.1 per cent; October, 167,500,000 kw.-hr., 31.4 per cent; November, 168,400,000 kw.-hr., 30.9 per cent; December, 177,600,000 kw.-hr., 31.5 per cent.

The figures that are given are based on the operation of about 4,000 power plants, each producing 10,000 kw.-hr. or more per month, engaged in generating electricity for public use, including central stations, electric railway plants, and certain other plants that contribute to the public supply.

Chicago May Be Granted Temporary Diversion

The Secretary of War has announced his intention to hold hearings in Washington the week of Feb. 16 in connection with the request of the Sanitary District of Chicago to divert an annual average of 10,000 sec.ft. of water from Lake Michigan. The Chief of Engineers has recommended a five-year permit to divert 8,500 sec.ft. annual average and 11,000 sec.ft. instantaneous maximum, conditional upon the carrying out by the District of its sewage disposal program, the participation of the District in the cost of lake regulating works and the starting within six months by the City of Chicago of a 90 per cent metering program to be completed 10 per cent each year.

The Secretary has also asked the Attorney General to rule on the Secretary's legal authority to grant a permit for a diversion greater than 4,167 sec.ft.

Federal Trade Commission To Investigate the G. E. Co.

The Senate by vote of 55 to 25 on Feb. 9 adopted the Norris resolution providing for an investigation of the General Electric Co. by the Federal Trade Commission. To the resolution approved by the Interstate Commerce Committee Senator Norris added a paragraph instructing the Commission to investigate also any effort that may have been made by the General Electric Co. "or any one in its behalf, or in behalf of any trade organization of which it is a member, through the expenditure of money or through the control of the avenues of publicity, to influence or control public opinion on the question of municipal or public ownership of the means by which power is developed and electric energy is generated and distributed." This addition to the resolution was adopted. Senator Norris contends that there has been large-scale propaganda in an effort to discredit municipal ownership of public utilities.

An effort on the part of Senator Harrison of Mississippi to broaden the investigation to include all power companies was voted down 21 to 56.

Senator Watson of Indiana attempted to amend the Norris proposal by precluding the investigation of stockholders or other security holders of the General Electric Co. The amendment was opposed on the ground that it was

necessary to investigate more than the General Electric Co. proper to establish whether or not a monopoly exists and that this could not be done without examining stockholders. The Watson amendment was rejected by a vote of 32 to 43.

No Shortage of Oil Expected by Oil Men

In the annual number of the *Oil and Gas Journal*, J. Edgar Pew, president of the American Petroleum Institute, expressed the opinion that "the condition of the oil business is better than it has been for several years. Mr. Pew says in part:

"Within the industry there is a better spirit of co-operation for the benefit of all. Standards of equipment are being established that should very considerably reduce the costs of materials and increase the efficiency of all field labor. Drilling operations are conducted with better success as a result of geological data, largely developed within the past few years. New pools of oil are being discovered with greater frequency and with less of the wildcat type of operations than ever before.

"The relations of the industry to the public are improving. The problems confronting the industry, its responsibilities and its great achievements are being better understood.

"I do not look with alarm upon any prophecies of a scarcity of oil during this year, or for many years to come. The oil industry has in a big way accomplished the seemingly impossible in the amount of oil it has produced, notwithstanding repeated predictions to the contrary that there was no such amount of oil to be had. I am confident that the precedent of its past performances will be fully maintained for many years to come, and until science and invention shall have provided a good and sufficient substitute for oil products. This seems to me to be a safe presumption. On the whole, the future of the legitimate oil business looks very bright."

Production of Coal in 1924 Estimated

Estimates by the Geological Survey, place the total output of bituminous coal in 1924 at 483,280,000 net tons. These estimates are based on weekly reports of cars loaded by the 137 principal coal-carrying roads, furnished through the courtesy of the American Railway Association. Comparison of the Survey's figures with those from other sources, such as state departments of mines, geological surveys, operators' associations, etc., have been made where possible, and in some cases the original figures have been adjusted to agree with the best information available.

The figures reveal a sharp decline in output in Pennsylvania, Illinois and Indiana. As against 171,879,913 tons in 1923, the mines in Pennsylvania produced approximately 123,530,000 tons in 1924, a decrease of about 28 per cent. In Illinois and Indiana the decreases were 14 and 15 per cent respectively. Of equal interest and significance was the increase of more than two million tons in West Virginia, which carried the output of that state to a new high record of 110,000,000 net tons. A new high mark, 45,000,000 tons, was also established by Kentucky, despite the fact that many mines in the western part of the state were shut down most of the year by strikes.

Coming Conventions

American Association of Engineers. C. E. Drayer, 63 East Adams St., Chicago, Ill. Convention at Orlando, Fla., June 2-5.

American Association of Oil Burner Manufacturers. Leod D. Becker, Bank of Galesburg Bldg., Galesburg, Ill. Convention and exhibit at Edgewater Beach Hotel, Chicago, April 1-3.

American Electrochemical Society. Dr. Colin G. Fink, Columbia University, New York City. Convention at Niagara Falls, April 23-25.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Convention at St. Louis, April 13-17. Annual convention at Saratoga Springs, June 22-26.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 22-26.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Milwaukee, Wis., May 18-21.

American Water Works Association. W. N. Niesley, 170 Broadway, New York City. Convention at Louisville, Apr. 27-May 3.

Canadian Association of Stationary Engineers. Geo. J. Soucy, 48 Moore Ave., Toronto, Ont., Secy. Convention at Windsor, June 29-July 1.

Electric Power Club. S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Convention at Hot Springs, Va., May 26-29.

Exposition of Inventions—American Institute, E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Bldg., 29 West 39th St. New York City, April 27 to May 1.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

Mid-West Power Show at Milwaukee, Wis., May 18-21. Ralph H. Cahill, care of Mid-West Power Show, City Hall, Milwaukee, Wis.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Kansas Association** at Topeka May 6-8. J. M. Van Sant 739 Horne St., Topeka. **Pennsylvania Association** at Pittsburgh, Pa., May 15-16. Frank J. McCarron, 3647 North 11th St., Philadelphia, Pa. **Wisconsin Association** at Milwaukee, May 18-22. F. W. Horn, 256 29th St., Milwaukee, Wis. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **New England States Association** at Worcester, Mass., June 18-20. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Ohio Association** at Middleton, Ohio, June 18-20. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven. **Michigan Association at Muskegon,** July 15-17. Charles Unterreiner, 5522 Underwood Ave., Detroit, Mich. **Minnesota Association** at St. Paul, Aug. 24-28. C. A. Nelson, 800 22nd Ave., Minneapolis, Minn.

National District Heating Association. D. L. Gaskell, Greenville, Ohio. Sixteenth annual convention at West Baden Springs Hotel, West Baden, Ind., May 19-22.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, National convention at Hotel Winton, Cleveland, Ohio, May 6-8.

Personal Mention

J. E. Hauser, formerly with the Sinclair Pipe Line Co., has just resigned to become a member of the engineering firm of Hauser-Glenn Engineering Co., 214 Water St., Waxahachie, Texas.

H. W. Brooks, fuel engineer of the United States Bureau of Mines, has announced his resignation of this position, effective Feb. 15, in order to join the consulting staff of the Fuller-Lehigh Co., Fullerton, Pa., manufacturer of pulverized fuel equipment.

Ralph G. Johansen, formerly of the Alexander Hamilton Institute and the Hamilton College of Law, has assumed charge of the Hays Institute, the combustion and fuel engineering correspondence school, at 1412 Michigan Ave., Chicago, which offers five courses on combustion for engineers and firemen.

Dr. Earl Page, minister of state for the treasury of the Commonwealth of Australia, with his staff and family, is making an extended tour of the Pacific Coast. He is interested in and making a study of hydro-electric power developments, but is primarily interested in the standardization of generation and transmission voltages and in the application of electricity to rural uses.

Erik G. W. Lindquist, first engineer, hydraulic laboratory, of the Royal Institute of Technical Sciences, Stockholm, Sweden, is visiting the United States studying the equipment of hydraulic laboratories here. He expects to visit various university and other laboratories before returning to Sweden. His present address is 32 Clark St., Danvers, Mass.

Society Affairs

The Chicago Section of the A. I. & S. E. E. will hold a meeting at the Atlantic Hotel on Feb. 26. The subject will be "Can the Synchronous Motor Be Successfully Applied to Steel Mill Main Drives?"

The Colorado Section of the A.S.M.E. will hold a meeting at the Metropole Hotel, Denver, on Feb. 27. An excursion to the Lacomb power plant or Lakeside power plant of the Public Service Co., Denver, Colo., will follow.

The New Haven Section of the A.S.M.E. will have as the subject of its March 3 meeting, to be held at the Mason Laboratory, "Steam Loss Prevention," by Henry M. Burke, plant engineer of the Mount Hope Finishing Co., North Dighton, Mass.

The Providence Engineering Society, 44 Washington St., Providence, R. I., has as members of its Power Section: Francis M. Willett, chairman; Albert B. Coop, vice-chairman; Mark A. Golrick, secretary. The section is making a membership drive.

Business Notes

The Blodgett Engineering & Tool Co., Detroit, Mich., has added to its staff Roy Gill as a special sales and service representative.

The Foster Engineering Co., 109 Monroe St., Newark, N. J., announces that as of Jan. 1, George H. Bauer, connected with the company for some time, was appointed assistant general manager of sales.

The Chicago Pneumatic Tool Co., Chicago, Ill., has recently entered into an agreement, whereby it will become the exclusive distributor in the United States of the Pedwyn balancer, a device for suspending, lifting and balancing electric and pneumatic portable tools. These balancers will be carried in the branch and service stations of the company.

The Bailey Meter Co., Cleveland, Ohio, has just announced that it has recently entered into an agreement with Industrial Combustion Engineers, Ltd., Astor House, Aldwych, London, W. C. 2, England, whereby the latter are the sole licensees for the sales and manufacture of the Bailey meter equipment in Great Britain, France, Belgium and Holland.

The Scott Valve Manufacturing Co., Detroit, Mich., announces the following appointments: Russell F. Kleinman will be its representative at the Land Title Bldg., Philadelphia, Pa., for eastern Pennsylvania, southern New Jersey, Maryland, Delaware and the District of Columbia; The Chas. H. Tinker Co., 201 Devonshire St., Boston, Mass., will represent the firm in the New England territory.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack (*Coal Age*):

Bituminous, Net Tons	Market Quoting	Feb. 9, 1925
Pool 1	New York	$2.50@$3.00
Smokeless	Boston	1.72
Clearfield	Boston	1.75@ 2.20
Somerset	Boston	1.90@ 2.35
Kanawha	Columbus	1.50@ 1.70
Hocking	Columbus	1.50@ 1.75
Pittsburgh	Pittsburgh	1.90@ 2.00
Pittsburgh gas slack	Pittsburgh	1.40@ 1.50
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	2.15@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.25@ 1.50
Big Seam	Birmingham	1.50@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1.	New York	$2.25@$3.15
Buckwheat No. 1.	Philadelphia	2.50@ 3.00
Birdseye	New York	1.60@ 1.75

FUEL OIL

New York—Feb. 11, light oil, tank-car lots; 28@34 deg. Baumé, 5⅔c. per gal.; 36@40 deg., 6c. per gal., f.o.b. Bayonne, N. J.

St. Louis — Feb. 3, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.10 per bbl.; 26@28 deg., $2.15 per bbl.; 28@30 deg., $2.20 per bbl.; 30@32 deg., $2.25 per bbl.; 32@36 deg., gas oil. 6c. per gal.; 38@40 deg., 7c. per gal.

Pittsburgh—Feb. 3, f.o.b. local refinery; 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6½c. per gal.

Dallas—Feb. 7, f.o.b. local refinery, 26@30 deg., $1.80 per bbl.

Philadelphia — Feb. 6, 28@30 deg., $2.73@$2.793 per bbl.; 18@22 deg., $2.42@$2.483; 13@16 deg., $2.10@$2.163 per bbl.

Boston—Feb. 9, tank-car lots, f.o.b.; heavy oil, 12@14 deg., Baumé. 4½c. per gal.; light oil, 28@32 deg. Baumé, 5¾c. per gal.

Cincinnati — Feb. 3, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6¼c. per gal.; 26@30 deg., 6¾c. per gal.; 30@32 deg., 7c. per gal.

Trade Catalogs

Filters—Graver Corp., East Chicago, Ind. Bulletin No. 501, "Horizontal and Vertical Pressure Type Water Filters," describes filtration methods of the Graver filter. Tables of sizes and capacities are included.

Heater. — Griscom-Russell Co., 90 West St., New York City. Form 202 describes the G-R instantaneous heater to supply hot water in hotels, apartments, laundries, factories, dyehouses and wherever large quantities of water are to be heated by live or exhaust steam.

Steam Flow in Pipes — Walworth Manufacturing Co., Boston, Mass. "Watts Charts" is the title of a valuable leaflet recently issued by this company, selling agents for the Watts Regulator Co. The leaflet contains curves or charts for the solution of Babcock's formula for the flow of steam through pipes. The factors involved are the weight of steam passing per minute, the length of the pipe, the pressure drop, the density of the steam and the internal diameter of the pipe. Any unknown factor can be quickly found by the use of these charts.

New Plant Construction

Calif., Delano—Central California Ice Co., Mono and P Sts., Fresno, is having plans prepared for the construction of an ice plant here. The first unit, with a capacity of 60 tons per day, to be erected now.

Calif., Long Beach—Davies and Lockridge, Archts, Farmers & Merchants Bank Bldg., are preparing preliminary plans for the construction of 12 story apartment, on East Ocean Blvd. Estimated cost $1,000,000. Owner's name withheld.

Calif., Los Angeles — Broadway Properties Inc., c/o G. A. Lansburgh, Hillstreet Bldg., Archt., awarded contract for the construction of a 13 story, lofts and theater building, on South Broadway, to J. V. O'Neil, 5860 South Park Ave. Heating, ventilating, elevators and refrigeration, not included in contract. Estimated cost $1,000,000. Orpheum Theater, 630 South Broadway, is lessee.

Calif., Los Angeles—Department of Public Service, Public Service Bldg., will receive bids until February 20, for Diesel engine, generating set.

Calif., Los Angeles—A. Soiland, 10407 South Hope St., is having plans prepared for the construction of a 9 story, office building, on Hope St. Estimated cost $750,000. J. J. Frauenfelder, Story Bldg., is architect.

Calif., Oakland — County of Alameda, G. E. Gross, Clk., will receive bids until March 2, for mechanical equipment for power house, at County Hospital (Highland).

Calif., San Francisco—Canterbury Hotel Co., c/o Weeks & Day, 315 Montgomery St., plans the construction of a 15 story hotel, at Mason and California Sts. Estimated cost $5,000,000.

Calif., San Francisco—Mason-Sacramento Corporation, 43 Sutter St., awarded contract for the construction of 10 story community apartments, at Mason and Sacramento Sts., to Clinton Construction Co., 923 Folsom St. $1,000,000. M. V. McAdam is president.

Calif., San Francisco—Sanitary Laundry Co., 15 McCoppin St., plans to convert building into laundry, and install ventilating system, power plant, boiler room equipment, etc. Estimated cost $250,000.

Calif., San Francisco—W. B. Wagnon, 325 Bush St., plans the construction of a theatre, office and store building, on recently purchased site, at Market and Hyde Sts. Estimated cost $3,000,000. Alexander Pantages, Pantages Theatre Bldg., is leasee.

Calif., Tracy—Ohm & Raab, 517 East Market St., Stockton, Engrs., are preparing plans for the irrigation of 1,055 acres, involving an earth ditch, 7,700 ft. long, 13 ft. wide at top, 5 ft. at bottom, and 2 ft. deep; pumping plant with 2 horizontal centrifugal pumps, 10 in and 18 in. capacity 13.6 sec.ft., total lift 51 ft., to be operated by 125 hp. electric motors; pipe line, etc. Owners name withheld.

Colo., Denver—Famous Players—Lasky Corporation, 485 Fifth Ave., New York City, plans the construction of a theatre and office building. Estimated cost $1,000,000. Engineer and architect not selected.

Conn., New Haven—Durham Storage Co., 35 Olive St., is having plans prepared for the construction of a 3 story, cold storage plant on Olive St. Estimated cost $75,000. Refrigerating machinery and motors to be installed. Westcott & Mapes, Inc., 207 Orang St., are engineers and architects.

D. C., Washington—A. L. Flint, Gen. Pur. Officer for the Panama Canal, will receive bids until February 25, for motors, air compressors, electric cable and wire, panel boards, etc. (Spec. 1653).

D. C., Washington — U. S. Engineers Office, War Department, rejected bids for furnishing gasoline engine, centrifugal pumping set. Bids will be readvertised.

Fla., Ormond—Bd. of Managers, D. P. Carnell, Chr., will receive bids until March 10th for the construction of a complete waterworks system, including drilled wells, centrifugal pumps, pumping station, etc. Main Engineering Co., Daytona, is engineer.

Fla., Vero—City Council, B. T. Redstone, mayor, will receive bids until March 2, for sewer improvements, including 2 sewerage pumping plants.

Ill., Great Lakes—U. S. Veteran Bureau, Room 791, Arlington Bldg., Washington, D. C., will receive bids until March 17th, for the construction of several hospital buildings, here, including heating plants, elevators, ice making and refrigerating plant, etc.

La., Donaldsonville — Light and Water Commission will receive bids about April 1, for the construction of a new filtration plant. Equipment includes electric driven pump. J. W. Billingsley, Interstate Bank Bldg., New Orleans, is consulting engineer.

La., Jonesville—The Town, voted $40,000 bonds for improvements to water works and electric light system. F. P. Joseph, Glenmora, is consulting engineer.

La., Mansura—City will receive bids until February 25, for the construction of electric light plant and water works system, estimated cost $60,000. F. P. Joseph, is consulting engineer.

La., Metairie Ridge—Metairie Ridge Ice Co., C. H. Behre, president of Pelivan Ice Co., St. Louis and Villera Sts., New Orleans, and others, are having plans prepared for the construction of an ice plant, here. Estimated cost $100,000. Private plans.

Kan., Nocatur—City plans an election, to vote $40,000 bonds for water works, including pumping equipment, tank on tower, distribution lines, etc. C. A. Haskins, 822-24 Finance Bldg., is engineer.

Md., Baltimore—Hochschild, Kohn & Co., Howard and Lexington Sts., is having plans prepared for the construction of a 6 or 8 story department store at Howard, Franklin, and Center Sts. Estimated cost $2,000,000. J. E. Sperry, Calvert Bldg., is architect. H. F. Doelman, 507 No. Charles St. is engineer.

Md., Baltimore—M. Schaprio, J. R. Roney, H. Scherr, 313 So. Hanover St., plans the construction of a 12 story hotel and stores building, on Park, Howard and Center Sts. Estimated cost $4,000,000. Engineer and architect not selected.

Mass., Boston—Chamberlain & Co., c/o R. H. Wambolt, 6 Bacon St., Archt., is having plans prepared for the alteration of building for cold storage and refrigeration plant, at 28-32 Blackstone St.

Mass., Boston—Haines Furniture Co., 730 Washington St., C. Canner, Treas., plans the construction of a 14 story, office and store building, at Kneeland and Washington Sts. Architect not selected.

Mass., Boston—Park Square Hotel Corporation, c/o T. M. James, Archt., 3 Park St., is having preliminary plans prepared for the construction of a 16 story hotel, at Warrenton, Carver and Stuart Sts., Park Square.

Mo., St. Louis—Bd. of Public Service, Room 208, City Hall, will receive bids until March 10, for the refrigerating equipment for Union Market, including brine coils, piping, connections, valves, etc. Ammonia will be piped from central plant. Estimated cost $70,000. L. R. Bowen & H. Updike, 301 City Hall, are engineers.

Mo., St. Louis—Roxana Petroleum Co., Arcade Bldg., is receiving bids for the construction of a 12 story office building, at Locust Blvd. and 13th St. Estimated cost $1,000,000. Jamieson & Spearl, Arcade Bldg., are architects.

Neb., Falls City—M. Naylor, city clerk, will receive bids until February 25, for the construction of a pump house, and intake on the Nemeha River; filter plant, and alteration to reservoir; two direct connected motor driven centrifugal pumps, 750 g.p.m. and 500 g.p.m. capacity. Prince-Nixon Engineering Co., Omaha, Neb., is engineer.

Neb., Lincoln — Commonwealth Investment Co. is receiving bids for the construction of a 12 story office building, with vacuum heating system. Estimated cost $800,000. C. H. Larsen & Co., Fraternity Bldg. is architect.

Neb., Stanton—W. E. Cook, city clerk, will receive bids until February 17th for 350 gpm. triplex pump; two 8 in. wells, 60 ft. deep, with fittings, connections, etc., and installation.

N. J., Jersey City — Hudson County Maternity Hospital is having plans prepared for the construction of a hospital including steam heating system. Estimated cost $1,000,000. C. Ziegler, 75 Montgomery St., is architect.

N. J., Newark—Prudential Insurance Co., Prudential Bldg., awarded contract for the construction of a 16 story office building, on Halsey St., to Thompson Starrett Co., 49 Wall St., New York. Estimated cost $6,000,000.

N. J., Passaic—Eagle Iron and Brass Foundry is in the market for 12 x 10 in. air compressor, two 60 hp. 200 d.c. motors.

N. Y., New York—Broadway Chelsea M. E. Church, 701 West 177 St., C. Reisner, Chm., had plans prepared for the construction of a church and office building, including steam heating system, at Broadway and 174 St. Estimated cost $4,000,000. Werner-Nygren, 101 Park Ave., are engineers. Donn Barber, 101 Park Ave., is architect.

N. Y., New York — Culver Association, 342 Madison Ave., is having plans prepared for the construction of a 9 story apartment, including steam heating system, on West 99th St. Estimated cost $500,000. Townsend, Steinle & Haskell, 8 West 40th St., are engineers.

N. Y., New York—Department of Public Welfare, Municipal Bldg., had plans prepared for the construction of a hospital, including steam heating system, at Walton Ave. and 167 St. Estimated cost $3,200,000. C. B. Meyers, 31 Union Sq., is architect.

N. Y., New York—Jewish Maternity Hospital, c/o A. W. Brunner, 101 Park Ave., Archt., is having plans prepared for the construction of a hospital at 108th St. and Fifth Ave. Estimated cost $1,250,000.

N. Y., New York—Long Beach Operating Co., c/o Shampan & Shampan, 189 Montague St., Brooklyn, Archts., is having plans prepared for the construction of an 18 story loft building, on West 37th St. Estimated cost $900,000.

N. Y., New York—Real Estate Board, c/o Starrett & Van Vleck 810 40th St., Archts., will soon receive bids for the construction of a 16 story office building, at 14 East 41st St. Estimated cost $1,000,000.

N. Y., New York—M. Rosenthal, c/o M. Whitnston, 116 West 39th St., Archt., is having plans prepared for the construction of a 16 story loft building including steam heating system, at 443 Sixth Ave. Estimated cost $1,000,000.

N. Y., New York—Townsend, Steinle & Haskell, 8 West 40th St., Archts., are preparing plans for the construction of an apartment including heating plant, at 35 West 9th St. Estimated cost, $650,000. Owner's name withheld.

N. Y., New York—224 West 49th St. Co. Inc., D. Darrow, Pres., c/o H. J. Knapp, 1650 Broadway, Archt. and Engr., will build a 15 story hotel and theater building, including steam heating system, at 224 West 49th St. Work will be done by separate contracts under supervision of architect. Estimated cost $1,200,000.

N. C., Greensboro—Greensboro Bank and Trust Co. plans the construction of a 15 story hotel, on the side of Orpheum Theater, here. Estimated cost $900,000.

O., Cincinnati—City Hospital, Burnet Ave., plans the construction of a 5 story children's hospital, on Elland St. Estimated cost $1,000,000. Elzner & Anderson, Denton Bldg., are architects.

O., Cincinnati — Schwartz Realty Co., 303 Provident Bank Bldg., plans the construction of an 8 story apartment house, on Reading Rd. Estimated cost $2,000,000. O. Schwartz, 303 Provident Bank Bldg., is architect.

O., Cleveland—C. H. Kleinman, 1237 East 102nd St., representing owners, plans the construction of an 8 story, commercial hotel, including steam heating system, on East 18th St. Estimated cost $600,000.

O., Dayton—Harry & Lewis, 4th and St. Claire Sts., plans the construction of a 4 story building, for storage and refrigeration of market produce, on St. Claire St. Estimated cost $250,000. Complete refrigeration plant will be required.

O., Mansfield—Mansfield Tire and Rubber Co., C. W. Stevens, Purch. Agt., is in the market for 350 hp. motor.

Okla., Morrison—The city clerk will receive bids until February 18th for waterworks improvement including well, tank on tower, pumps, valves, mains, etc. $27,000 bonds voted for project. H. G. Olmsted, 2239 West 18th St., Oklahoma City, is engineer.

Okla., Oklahoma City—G. T. Blankenship, Braniff Bldg., is having plans prepared for the construction of a 10 story apartment house on Robinson St. Estimated cost $1,000,000. Hawk & Parr Cotton Exchange, are architects.

Okla., Toukawa—City plans the construction of a dam across the Chikaskia River, including settling basins, filter plant, motor driven pumping equipment, mains, valves, etc. Estimated cost $80,000. Ruckel Engineering Co., Hutchinson, Kan., is engineer.

Tenn., Nashville—American Trust Co., 235 Third Ave. North, P. D. Houston, Pres., is having preliminary plans prepared for the construction of a 14 or 15 story bank and office building at Third and Union Sts. Estimated cost $800,000. H. C. Hibbs, Fourth and First National Bank Bldg., is architect.

Tenn., Nashville — Nashville Hardwood Flooring Co., in the market for a left hand double eccentric Corliss engine, equipped for rope drive to develop between 400 to 500 hp. at 135 lb. steam pressure. Must have grooved driven pulley, tension carriage, etc., to produce line shaft speed of 300 r.p.m. Prefer Hamilton, Filer-Stowell or Allis-Chalmers (used).

Tex., Big Lake—J. P. Kittrell is in the market for a 150 hp. Y. Fairbanks-Morse, or equal, oil engine, with generator equipment.

Tex., Comanche—City plans water works improvements including additional mains, pumping equipment, etc. $70,000 bonds voted. J. B. Hawley, 403 Cotton Exchange Bldg., Fort Worth, is engineer.

Tex., Corpus Christi—P. G. Lovenskiold, c/o N. Wereskiold, 402 Marvin Bldg., Dallas, is receiving bids for 3 low service centrifugal pumps, 1,400 gpm. each; 3 high service centrifugal pumps, two 1,050 and one 700 gpm.; all electrical operated and two 150-200 hp. Diesel engines, direct connected to generator.

Tex., Dallas—Vaughn Mfg. Co., Elmit and Good Sts., is in the market for one 10 hp. or two 5 hp. motors.

Tex., Edinburg—Hidalgo Water Improvement Co., Dist No. 4, awarded contract for the construction of a pumping plant to be used in connection with the Hidalgo County irrigation project and equipment including 2,000 hp. full Diesel engines, and centrifugal pumps, to deliver 337.5 sec. ft, etc., to Fairbanks Morse & Co., North Market St., Dallas. $129,050.

Tex., Houston — J. H. Jones, Groggan Bldg., is having preliminary plans prepared for the construction of a theater and office building, here. Estimated cost $1,000,000. Private plans.

Tex., Killeen—City will hold election February 18th to vote $16,000 bonds for water works improvement including pumping equipment,, mains, etc. J. L. Swope is secretary.

Tex., Pharr—City voted $20,000 bonds for water works improvement including mains, pumping equipment, etc. Engineer not selected.

Tex., San Antonio—Commercial Reality Co. is having plans prepared for the construction of a 6 story theater and office building, on Commerce, St. Mary and Crockett Sts. Estimated cost $1,500,000. The Kelwood Co., 907 Travis Bldg., is architect. J. Oppenheimer is chairman of the building commission.

Tex., South Palestine—S. L. Watts, Tyler, and P. Horton, South Palestine, plan the construction of a 40 ton capacity ice plant here. Estimated cost $40,000. Complete equipment will be purchased. Private plans.

Tex., Stratford—City voted $20,000 bonds for construction of complete water and light plant, including pumping equipment, well, mains, electric dynamos, etc. Engineer not selected.

Tex., Wellington—City will receive bids about March 1st, for 400 hp. oil engine generator set for new electric light plant. Estimated total cost $55,000. V. V. Long & Co., Oklahoma City, are engineers.

Va., Alexandria—Northern Virginia Hotel Corporation will build a 6 story hotel here Work to be done by separate contracts under supervision of Day & Zimmerman, 1600 Walnut St., Philadelphia, Engrs. and Archts.

Va., Richmond — The Hockenbury System, M. G. Holtzman, representative and O. J. Parrish, president of Broad Street Bank, plan the construction of an 8 story hotel, here. Estimated cost $1,000,000. Engineer and architect not selected.

Wash., Zillah — Yakima Fruit Growers Association plans to expend $30,000 for improvements, including enlarging 50 ton icing plant, to 100 tons per day.

Wis., Milwaukee—English Woolen Mills, 204 Third St., will soon award contract for the construction of a 8 story office and store building on Wells St. Estimated cost $800,000. A. S. Alschuler, 283 Jackson Blvd., Chicago, is architect.

Wis., Milwaukee—Grand Manor Building Corporation, c/o M. Miller, 216 W. Water St., is having plans prepared for the construction of an 8 story apartment on Grand Ave. Estimated cost $500,000. M. Tullgren & Sons, 425 E. Water St., are architects.

B. C., Vancouver—Vancouver Ice and Cold Storage Co., Gore Ave., will receive bids in March for the construction of a 6 story cold storage plant at Gore Ave. and Railroad St. Estimated cost $150,000. Cold storage equipment will be purchased. McCorter & Nairne, 509 Richards St., are architects.

Ont., Cliff Beach—Township of Scarboro plans installation of two 1,000 gpm. electric, 3 stage centrifugal pumps, as auxiliaries. R. Harrison, c/o township office, 1361 Kingston Rd., Toronto, is engineer.

Ont., Toronto — Robins Limited, Rent Bldg., plans the construction of a 10 story office building, including steam haeting system, electric elevator, etc., on Bay St. Estimated cost $600,000. Engineer not selected.

S. A., Peru—Cerro De Pasco Corporation, 15 Broad St., New York City, will build an experimental leaching plant here. Owners will purchase equipment, including pumps, motors, etc. Estimated cost $200,000. Company engineers in charge.